A Memorandum

from

The President of Iceland

Ólafur Ragnar Grímsson

Drying of Food Products

A New Perspective on Global Food Security

Foundation for Projects in Developing Countries

Office of the President of Iceland

Reykjavík, May 2012

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Preface

by

Ólafur Ragnar Grímsson

President of Iceland

The Icelandic Experience:
Foundation for Food Projects in Developing Countries
Could Drying be a Basis for Revolutionary Change?

The food crisis is the profound challenge of the 21st century. The global population could reach 9-10 billion; resources are getting scarcer and a great deal of food is wasted or gets destroyed within a few days because effective storage methods are not available. In India it has been estimated that up to 20% of food gets destroyed within days due to the lack of long-time storage.

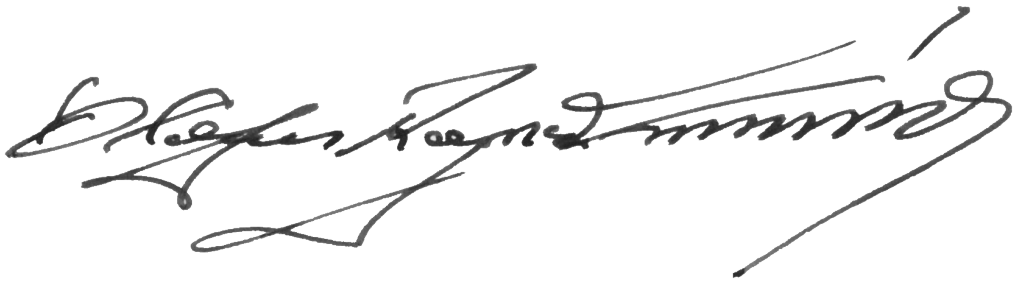
How can we maximize the productive use of food and make sure that every item is transformed into human consumption? The key can probably be found in applying cheap, effective and sustainable methods of storage; to make sure that every part of each food product – fish, meat, fruit and vegetables – is used for consumption.

For the most of the 20th century Icelandic fishing companies threw away fish heads, bones and other parts of the fish because only the filets were exported. In recent decades Icelandic fish producers have, in cooperation with geothermal technicians, developed a low-temperature method for drying all those parts of the fish that previously were thrown away. This has now led to a firmly established market for dried Icelandic fish in Nigeria; the storage time being expanded to 1-2 years without any special facilities.

This memorandum explains the Icelandic model in order to facilitate discussions on how to establish similar projects in developing countries. The next steps would then be to explore whether the drying method could become a major contribution to global food security. There are over 100 countries in the world which have low-temperature geothermal resources; wind and solar energy could also be used.

The memorandum is prepared by my office in cooperation with Icelandic fish producers with extensive experience of the dry fish market in Africa.

It is my hope that the memorandum could bring together different partners who are interested in exploring how the drying method of food could be implemented on a grand scale in developing countries.



Executive Summary

The purpose of this memorandum is to provide information about the accelerated drying of fish in Iceland and to explore how similar processes might be used for enhanced storage of food in developing countries where storage by cooling or freezing is too expensive or unpractical for other reasons.

The memorandum starts by explaining the tradition of drying fish with traditional methods in Iceland, where it was achieved either by spreading the fish on the ground for sun drying or by hanging it up for wind drying.

In recent decades Icelandic companies have preferred accelerated drying which was after 1950 driven by fossil fuels, then from around 1980 by use of clean, geothermal energy. As only low-temperature energy is needed to dry fish, and as low-temperature geothermal energy is widely accessible in the world, similar methods could be used in many places where drying counts as a practical method for storage. Furthermore, other sustainable energy sources, such as wind and solar energy, could play a significant role in accelerated drying where applicable.

The memorandum explains the key parameters of the drying process, what fish species have been used for drying in Iceland, what the markets and volumes are and suggests some other potential food products. The market aspect is also discussed; Nigeria has been the leading buyes of dried fish from Iceland where the product has a shelf life of 1-2 years and is a part of a significant value chain in the economy.

Finally, the memorandum offers suggestions regarding the next steps that could be taken to pursue these ideas by a partnership of institutions or international agencies that may see accelerated drying as one of the answers to the question how we can increase food security in the coming decades.

Contents

Historical Background

For centuries, Icelanders have preserved fish products by drying. It has been argued that in Viking times (AD 800-1000) drying of fish was an important precondition for the exceptionally wide-ranging voyages undertaken by Norse seamen who travelled to the Black Sea in the east and across the Atlantic to discover America in the west (Kurlansky, 1997). Dried fish or stockfish was extremely nutritious relative to weight and highly durable. Ever since, Icelanders have dried fish either by flattening the fish, salting it heavily and placing it on the ground for sun-drying or by hanging it on wooden stock frames for harnessing the additional benefit of the wind.

Salt fish laid on the ground for drying in Ísafjörður, Iceland, in the first half of the 20th century.

These methods were employed on a large scale in the first decades of the 20th century when salted and dried cod, known as *bacalao* in Spanish, became an important item of export to catholic countries, including Spain and Italy. Wind drying is still widely used in Iceland, even if other and more technologically advanced solutions have now become more common.

A Nigerian customer visiting the town of Dalvík, northern Iceland, against the background of stockfish drying on traditional stock racks.

The purposes of drying fish and other food can be summarized like this (cf. Soriao, 1987):

- To preserve the product for future use.
- To reduce bulk and weight for easier storage, transport and marketing.
- To condition raw materials for further processing, e.g. to recover liquid by-products, such as oil, from solids.

In past centuries, geothermal water was used sporadically for bathing but in the first decades of the 20th century Iceland began exploiting this valuable resource systematically for house heating. Then, in the last three decades of the century, geothermal energy has been harnessed for the production of electricity. Currently, Iceland produces more than 99% of its electricity by the use of either hydropower or geothermal, making around 80% of its total energy consumption sustainable. Fossil fuel for cars and the ships accounts for the remaining 20%.

Geothermal energy has proven to have a wide range of uses, other than the production of electricity. For decades it has been used effectively for heating of greenhouses; it supplies hot water for space heating, for outdoor swimming pools and spas, for snow melting in winter, and for thirty years it has been used on a rather large scale for drying of fish. In 1950 an Icelandic manufacturer, Landssmiðjan, built drying equipment based on a Canadian design for drying saltfish indoors; it was noted then that geothermal energy could be used for this purpose but transportation costs were thought to prevent this from being practical (Alþýðumaðurinn, 22 Aug. 1950). Later, when geothermal drilling had advanced, the idea was pursued and around 1980 a couple of companies started experimental drying of fish with geothermal heat. At present, a whole industry is based on this technique.

Arason (2003) summarizes the main advantages of indoors drying as compared with outdoors drying as follows:

- Drying time is shorter.
- Drying is possible all year round.
- Indoors drying offers a more consistent quality.
- Flies and insects are prevented from contaminating the product.
- Local energy sources are utilized.

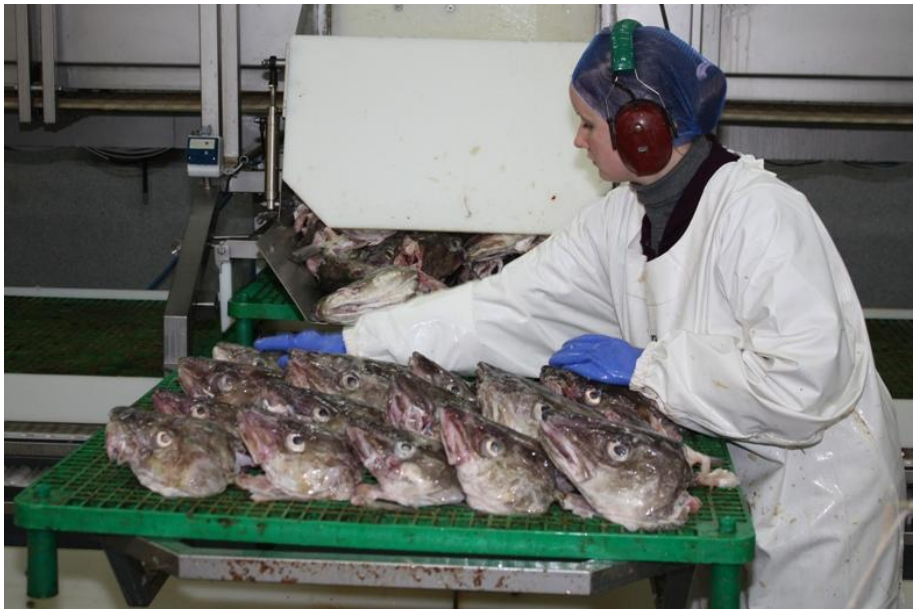
The Companies

Currently there are about 20 companies in Iceland using sustainable energy for drying of fish and most of them use geothermal heat (see list in Appendix 2). The companies are distributed over the seaside towns of Iceland, including Vestmannaeyjar, Hafnir, Dalvík, and Akranes, but a couple of them are removed from the coast such as Laugar and Egilsstaðir. One of the leading companies in this industry, Haustak, has a web site, haustak.is, which displays some useful information.

The Process

Drying of fish heads takes about 48 hours; then some further drying ("after-drying") at a lower temperature takes a bit more than that. The equipment needed for geothermal drying of fish does not have to be

technologically advanced but, given the access to a geothermal source, a closed compartment for drying is needed along with careful and constant control of temperature, air speed, and humidity. The geothermal source does not have to provide high-temperature since the optimal temperature range is 22-28° C. Higher levels would cook the fish and ruin the process.



Green, plastic drying frame, full of cod heads.

Arason (2003) outlines the key principles and fish drying based on the Icelandic experience. The drying has two separate phases. The first one, the period of constant drying, is characterized by a surface saturated with moisture. During this phase, air velocity, temperature and the level of humidity are key factors. The second phase is the period of falling drying rate. Then the effect of air velocity is reduced, and the drying is based on moisture moving gradually to the surface of the product.

Fresh cod heads contain 82% water; after primary drying the water is down to 55% and, after secondary drying, it is 15%. Arason and others have discovered that the optimal parameters for drying cod heads are having air temperature at 25°C, air speed at about 3 m/s and air humidity at about 45% (Arason, 2003).

In certain climates, including the tropics, conditions of high humidity and high outside temperature would certainly make the process

different from what is common in Iceland but the same physical principles apply.

In Iceland, companies began by using geothermal steam, directly from the source, for drying, and at the earlier stages methods and facilities were somewhat primitive. Drying frames were made of wood and the housing was small and not specially built for this purpose. Accelerated drying can take place with humble tools and still compare well with traditional drying. But technical training and sensible investments will obviously increase the chances of success.

Rather than directing geothermal steam into pipes that go directly into the drying space, Icelanders now prefer using the steam to heat water in heat exchangers because this makes it easier for them to control the level of temperature. To accelerate drying, electric ventilation fans are used, and in other locations electricity for this purpose may be generated from sustainable sources such as solar cells.

Some Icelandic producers use a robot for moving the products around inside the facility (cf. haustak.is), and conveyor belts are also used as are machines for other purposes, such as to assist with packaging or chopping. Also, they have developed an optimal type of drying tray as shown in the picture below, but initially the drying was done quite efficiently with primitive tools.

Loaded drying frames in drying compartment.

The final product of dried fish contains approximately 13% water which is why it is not well suited for vacuum packaging. Instead it is wrapped into juta bags, an organic fabric that provides perfect ventilation. The Icelandic companies declare that the shelf life of the product is one year but others maintain it is up to two years.

Production line in Iceland.

Organic Raw Materials

The species used for drying in Iceland are mostly tusk, ling, and cod. When the market price of capelin, saithe, and haddock is favourable, these species are also purchased for drying. As a rule of thumb, fat content of fish suitable for drying must not exceed 5%.

The organic raw materials may vary in preparation but the Icelandic producers receive fresh cod heads and backbones from freezing plants, where they were formerly thrown away as garbage. As far as chops are concerned, those are usually prepared in the drying plants before drying.

It is important to note that the raw material for drying must be fresh fish. When cooking a meal, the consumer quickly notices if the raw material is unsatisfactory, and drying never makes bad fish good.

The Products

Icelanders have used sun and wind dried fish for centuries in products such as *stockfish* (Icelandic: skreið; wind dried, no salt, with skin and bones but no head), *salt fish* (Icelandic: saltfiskur, French: morue, Spanish: bacalao, Italian: baccalà, Portuguese: bacalhau), *cod heads*, and *hardfish* (Icelandic: harðfiskur; filet snacks, wind dried, compressed).

In accelerated drying, which, as far as Iceland is concerned, is more or less equivalent to geothermal drying, the major products are heads, bones (or backbones), chops and filets. These products can contain up to 80% proteins and are highly nutricious.

Backbones: The bones are actually the spine and ribs of the fish which are redundant after the more valuable filet has been removed. Despite good cutting there is always a lot of useful tissue on the bones.

Chops (or cutlets): These are fine pieces of fish with few bones, a high-end product.

Filets: Filets of ling are dried and sold to Nordic markets for a local specialty called *lutefisk*.

Whole fish: One species, the star ray, has been dried with bones and head, without intestines.

Snacks: Protein-rich filets or small chunks are popular as snacks in Iceland (hardfish), and they are often produced by use of geothermal heat in small plants. These snacks are high in protein, while low in fats and thus very healthy compared with many other popular snack products (cf. Shaviklo et al., 2011).

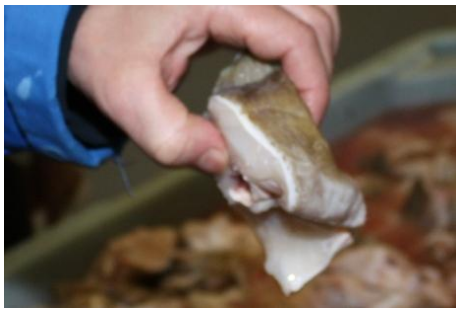
Pet food: Some producers have marketed dried, pelagic fish as pet food. Capelin has been used for this purpose but the fat content is below 5% only during two weeks in March so in order to use capelin it must be salted for storage (freezing is too expensive); during subsequent desalination some dry material is lost (Arason, 2003).

Grainy leftovers: During production some leftovers are generated, often in the form of fine-grained material. This material can be useful as food supplement in farming or as a fertilizer.

Wet backbone.

Half-dried backbone.

Bones in bag, compressed.



A fresh chop of linge.

Machine-cutting of chops.

Market-ready chops.

Dried filet of ling.

Dried, whole star ray.

The Market

Nigeria: Icelandic companies mainly export to Nigeria. This market has a tradition of consuming dry fish. Nigerian wholesalers also distribute imported dried fish to neighbouring countries.

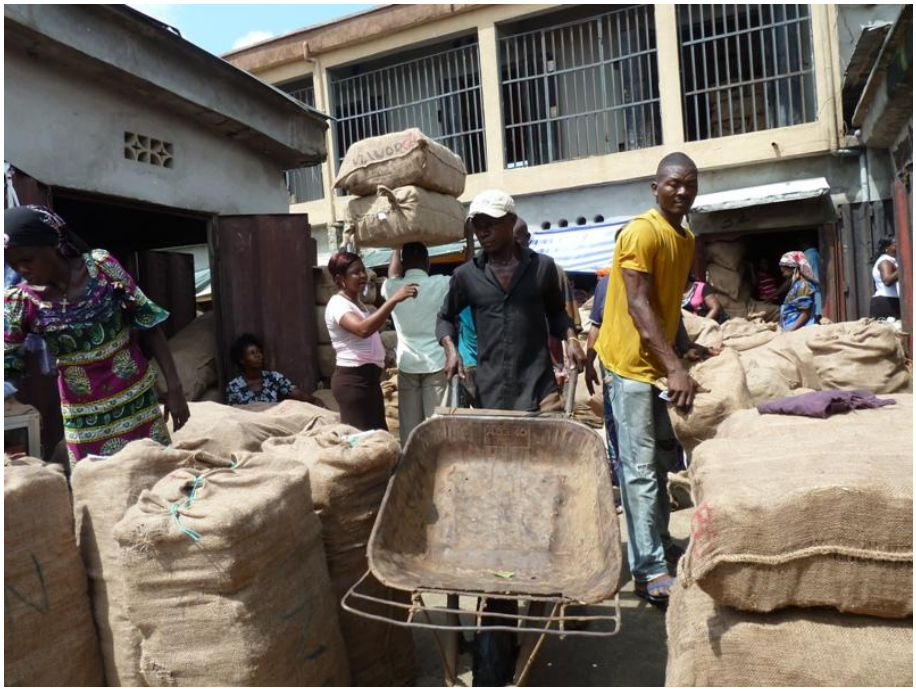
Nordic countries: This is primarily the lutefisk market in Norway.

Local market in Iceland: Icelanders have plentiful access to fresh fish (and to refrigerators) and the market for dried fish in Iceland is small. Still, there is some consumption of salt cod for meals and of hardfish for snacks.

It is noted that the Nigerian market is not only quite big but also demanding. In 2010 the dried fish exports from Iceland to Nigeria amounted to 16,000 metric tonnes (or 16,032,466 kilogrammes, export value: 5.4 billion ISK or 43 million USD by the March 2012 rate of exchange; cf. Vísindavefur). The total export income of dried fish products from Iceland amounts to approximately 70 million USD annually.

Dried fish is also exported from Canada, the Faroe Islands, Norway, and the UK (Árni Þór Bjarnason, 2011). Norwegians export dried fish on their own to Nigeria and they use natural gas for accelerated drying.

Dry fish packaged in jute bags imported from India.



Handling in a Nigerian warehouse.

Consumption

Bones are used in a way comparable to bouillon (or stock) cubes in Europe and the USA, and are typically added to a soup of vegetables for better taste and nutrition. The cutlets are a more expensive product and have the advantage of being sold in convenient sizes. Nigerians use a lot of vegetables in their cooking but often dried fish or crabs are used for garnishing. The taste of the course will mostly depend on the selection of spices.

Dried fish cooking Nigerian style.

Low temperature Areas World-Wide

With current technologies, it is feasible to produce electricity at temperatures as low as 80°C. Vast areas on the planet have access to geothermal heat at lower temperatures, sufficient for the drying of food. In 2010, 78 countries used geothermal energy for some purposes; even if 14 countries used geothermal for drying of agricultural products, the volume of this use as a proportion of total geothermal use is only 0.4% (Lund et al., 2010). All 78 countries currently using geothermal energy could use it for drying of food products such as fish. This is the list of 78 countries "having direct utilization of geothermal energy":

Africa: Algeria, Egypt, Ethiopia, Kenya, Morocco, South Africa, and Tunisia. Furthermore, Djibouti, Rwanda, and Uganda are preparing for utilization of geothermal energy.

The Americas: Argentina, Brazil, Canada, Caribbean Islands, Chile, Columbia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Peru, United States, and Venezuela. Furthermore, Greenland has hot springs that indicate possible utilization.

Asia: China, India, Indonesia, Iran, Israel, Japan, Jordan, Korea (South), Mongolia, Nepal, Philippines, Tajikistan, Thailand, Vietnam, Yemen. Also, Bangladesh, Saudi Arabia, and Abu Dhabi are like candidate states.

Europe: Albania, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Macedonia, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, and the United Kingdom.

Commonwealth of Independent States: Armenia, Belarus, Georgia, Russia, Ukraine.

Oceania: Australia, New Zealand, Papua New Guinea.

Clearly, most of these countries meet the technical requirements for utilizing geothermal energy for drying of food products. In many developing countries where the storage of food is a problem and freezing is very expensive, the geothermal drying process could be a highly interesting option.

Ample information on geothermal resources is available on the Internet (see e.g. www.geothermal-energy.org). In Asia, Indonesia and the Philippines are quite advanced in this area and in Africa, Kenya is a leader. Other East-African countries, including Ethiopia, Djibouti, Tanzania, Eritrea and Uganda, also have favourable natural conditions for utilizing geothermal energy on a fairly large scale.

The Potential for Other Food Products

The geothermal drying process is not limited to fish products, even if Iceland's expertise is strongest in that particular line of business. It is easy to anticipate that other foods may be dried with geothermal energy. Drying of fruit, edible fungi, and beef should be easy with this technique. It might be a good idea to look at products that are currently dried with more primitive and slower methods and study the feasibility of switching to the use of geothermal energy. One study to that effect has been conducted on the feasibility of using geothermal heat for drying tobacco leaves in Indonesia (Kumoro and Kristanto, 2003).

Many countries have a tradition of drying foods. In China, for example, there is a big and traditional market for dried funghi and dried shrimps. As for meat, Spain and Italy have dried ham (jamón serrano, prosciutto di Parma), the Faroe Islands have dried mutton (skerpikjöt), the Arabs have dried, spiced beef (basterma, pastrami), and the US have beef jerky. Icelanders do not have a tradition of dried meat but have recently started marketing dried lamb meat as a high-end product (cf. Magnús Guðmundsson and Óli Þór Hilmarsson, 2003). Several countries are familiar with dried peppers, apples, bananas, and other fruits, not to forget raisins. For more or less all these products accelerated drying might be worth considering.

In some places where there is a tradition of drying foods, there may be some negative feelings about this processing. Mr. Sighvatur Sigurðsson told the author that during a visit to Dubai he asked several people about traditional, dried fish, and discovered that people were somewhat embarrassed about this food, they were not proud of it and perceived it as primitive. But there certainly was a solid, domestic tradition there of drying fish from the Persian Gulf that Mr. Sigurðsson found highly interesting.

Icelanders have used geothermal energy successfully for drying seaweed for a couple of decades. The seaweed is harvested off the coast of western Iceland near a site where there is good access to geothermal energy and currently there are plans to expand this production. Icelanders have also used geothermal for drying barley, but this is only on an experimental scale so far. Icelanders are also using geothermal for extracting salt from sea water.

In the Philippines, people have also been using geothermal heat to produce salt. In 1986, the Philippines conducted a UNDP supported program for the "Development of Geothermal Energy for Power and Non-Electrical Uses" that mainly focues on the utilisation of geothermal energy agro-industrial uses (Soriao, 1987). The same source also explains how geothermal is used for drying coconut kernels, so-called copra.

Equipment Suppliers

Icelandic companies have developed and set up several fish drying facilities in Iceland. In 2007, a company called Samey delivered a cutting edge facility to UK customers. This unit was carefully designed based on

demands for low energy consumption and environmental factors. The problem of smell, which often follows drying of fish, was solved and two robots were included in the solution. The company cooperated with Marel and other Icelandic companies to deliver technical equipment, such as electronic scales, a packaging press and a hydrometer for dried fish (Morgunblaðið, 12 Feb. 2007).

Fish Drying in Namibia

An Icelandic technician worked in Namibia for approximately four years, trying to establish and run a fish drying unit there. The idea was to set up fish drying that would benefit from the arid and hot climate, Namibia being known for its deserts. The system was based on electric fans blowing hot and dry air onto the fish, which was hake from the South-Atlantic ocean.

The project eventually came to a halt for two reasons. One was related to marketing and the other to transport issues. The idea was to export the fish to Nigeria but the market there was not eager to accept the new product. Transportation turned out to be a problem because the containers had to be sent all the way to Spain and from there to Nigeria. The containers got very hot on the way, humidity accumulated near the top of the containers where the fish got too humid whereas it became too dry at the bottom.

Even if Namibia does have access to geothermal heat, it was not used in this case as calculations of availability of electricity and cost of transportation did not allow it.

No doubt, some valuable lessons can be learned from this project.

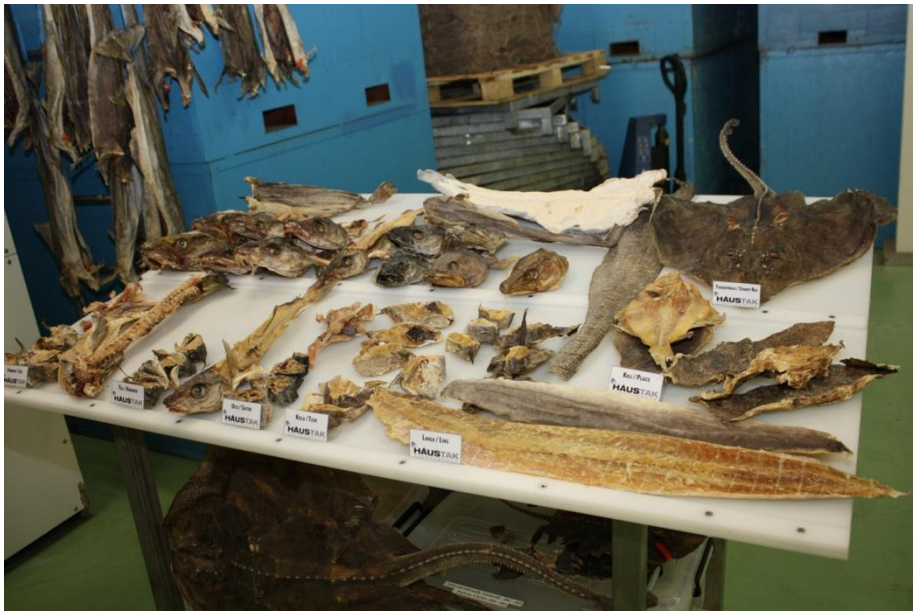
Next Steps

Here are some suggestions on how to develop this idea further:

- Create an informal working group involving representatives of interested institutions and foundations which are interested in creating a partnership to explore these ideas further.
- Examine a a few developing countries where pilot projects could be executed and thus gather experience of the drying method in differrent conditions and for different food products.
- Prepare a categorized list of food products that are currently or have recently been dried with slow or traditional methods. Categorize this list by countries, regions, and food groups (e.g. meat, fish, vegetable, fruits etc.).
- Prepare maps of low-temperature geothermal potential (and existing geothermal powerplants) and compare with maps of locations where suitable food candidates originate.
- Examine how localized solar and wind energy could be utilized for the same purpose.
- Prepare concrete business plans for drying of different food products in different countries and different localities.
- Develop new dried food products that are likely to be accepted in targeted regions; test them out in relevant markets.

Appendix 1. Photographs[1]

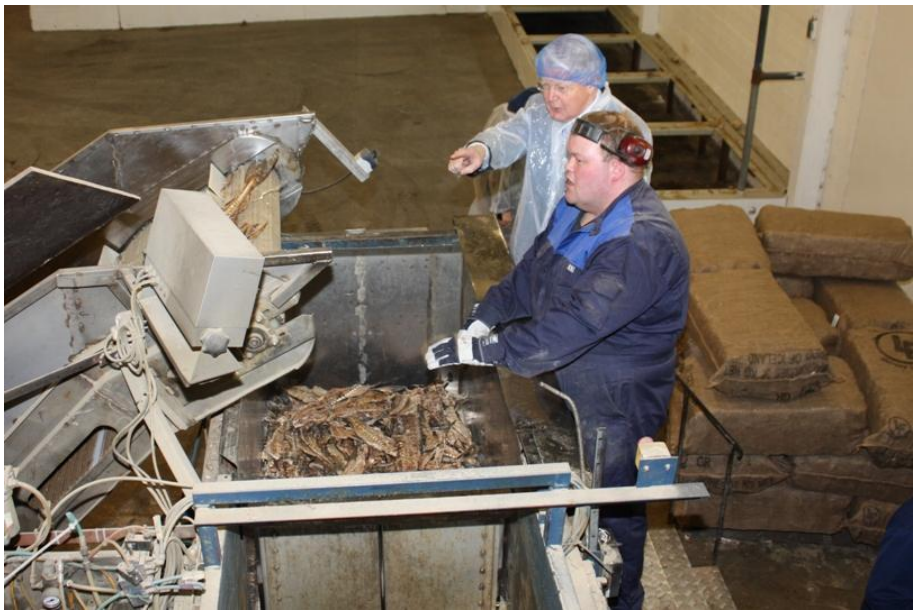
Fish drying in Iceland in 1994 with more manual processing methods.



Showcase of dried fish products from Haustak in Reykjanes, Iceland.

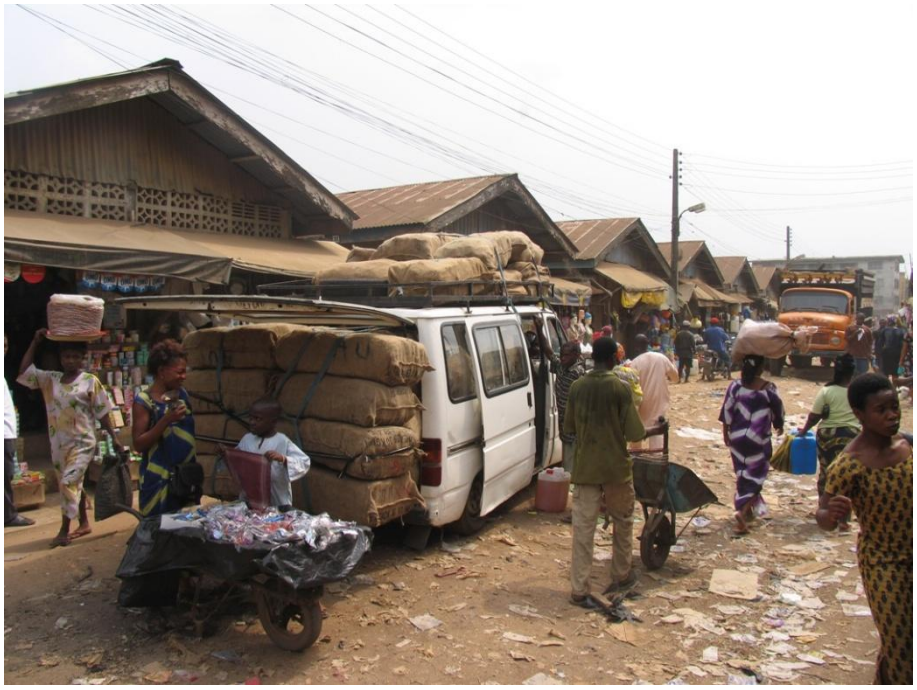
[1] Please note that some of the photographs may be subject to copyright.

Secondary drying – post-production storage in Iceland.

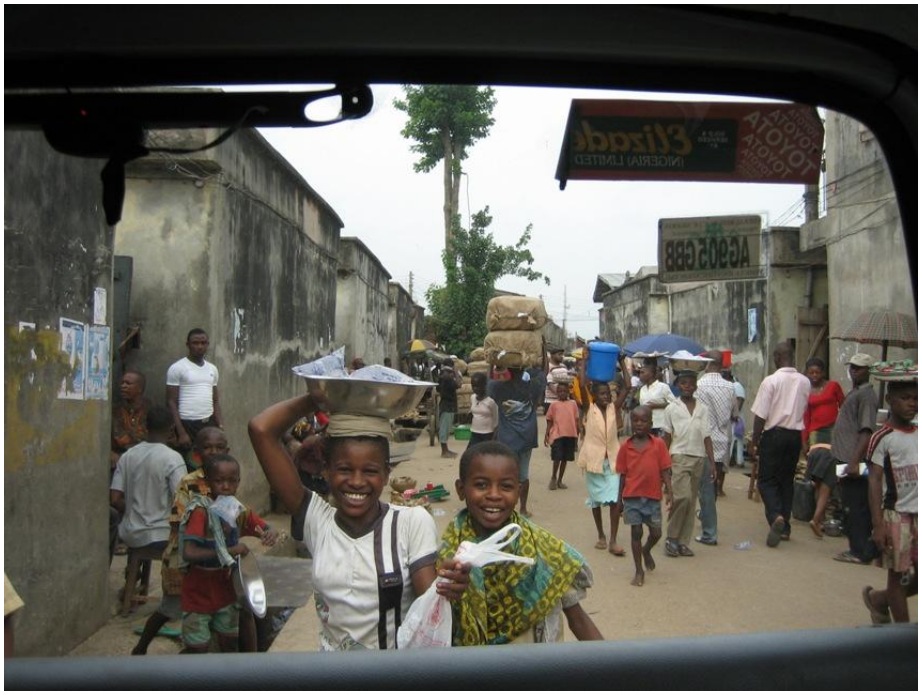


Pressing of bones and packaging into juta bags during President Grímsson's site visit to Laugafiskur in Akranes, Iceland.

Major warehouse in Nigeria for dried fish from Iceland.



A large delivery arriving to a local market in Nigeria.

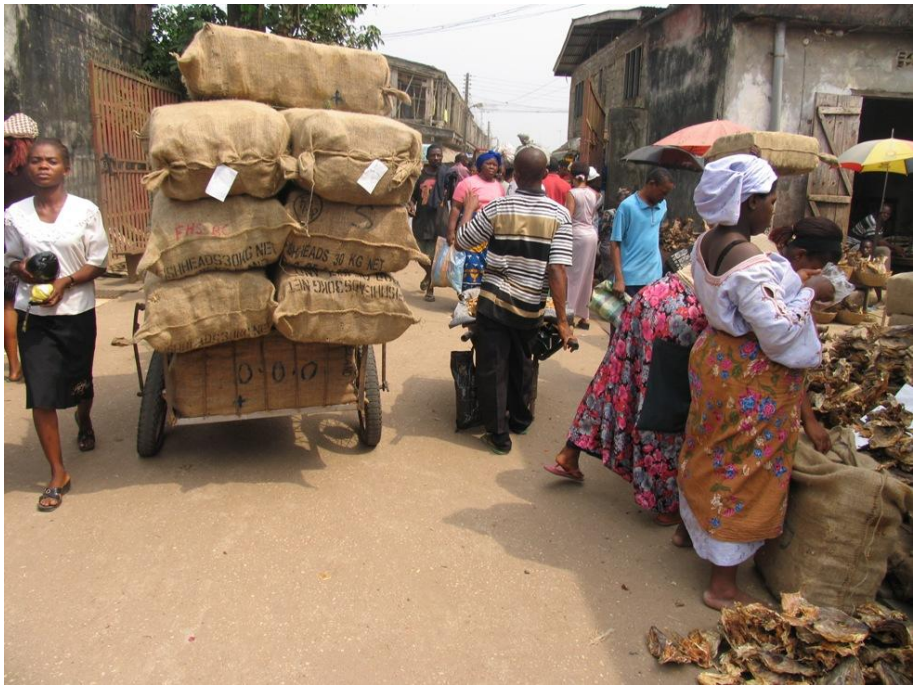


Happy youngsters at the fish market in Nigeria.

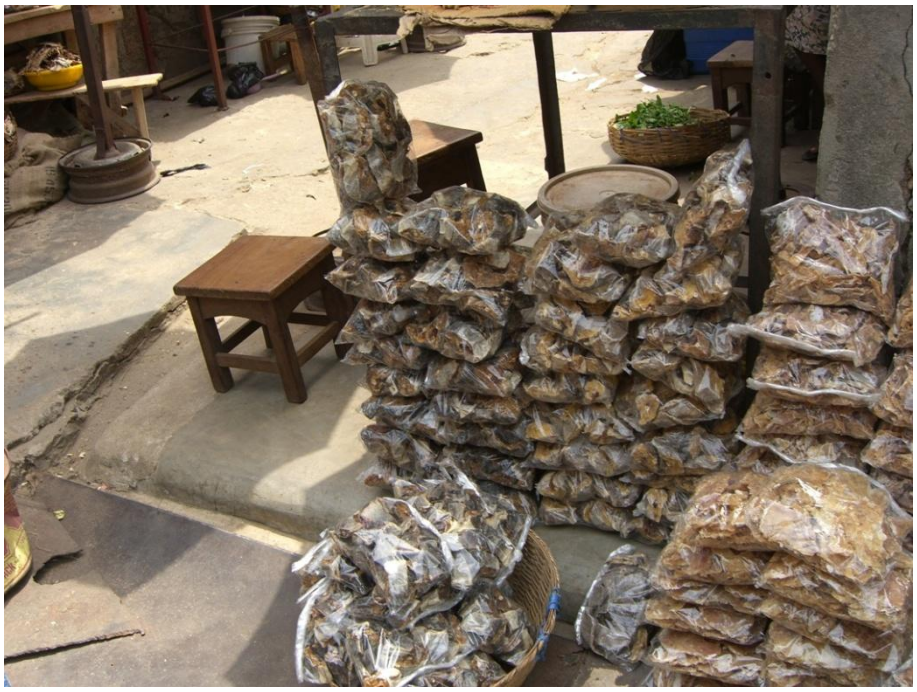
Savvy shopping in the Nigerian fish market.

Retail transaction on a sunny day in Nigeria.

View of a dry fish market in Nigeria.



Dried fish arriving to a market in Nigeria in juta bags.

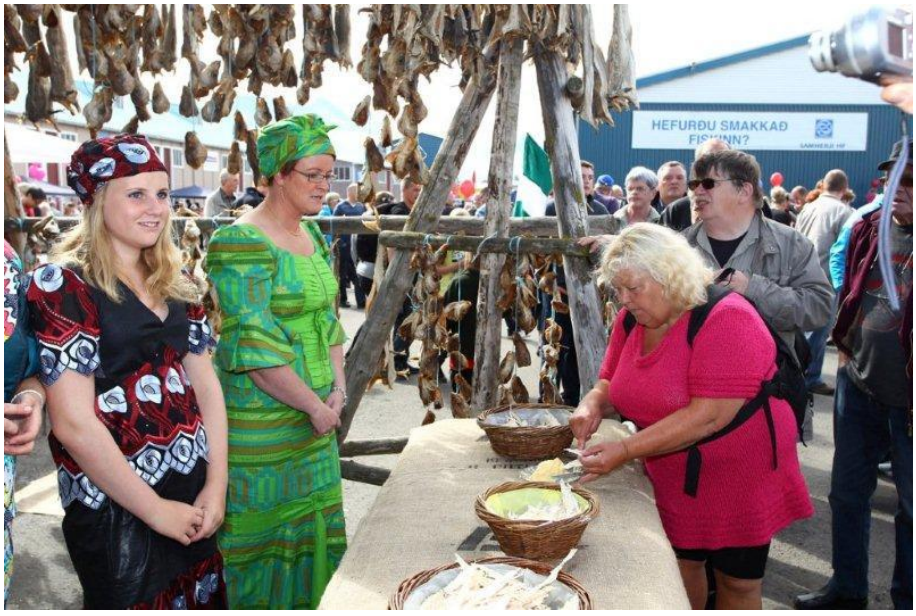


Dried fish in consumer packages in a local Nigerian market.

Dried fish retailing in Nigeria.

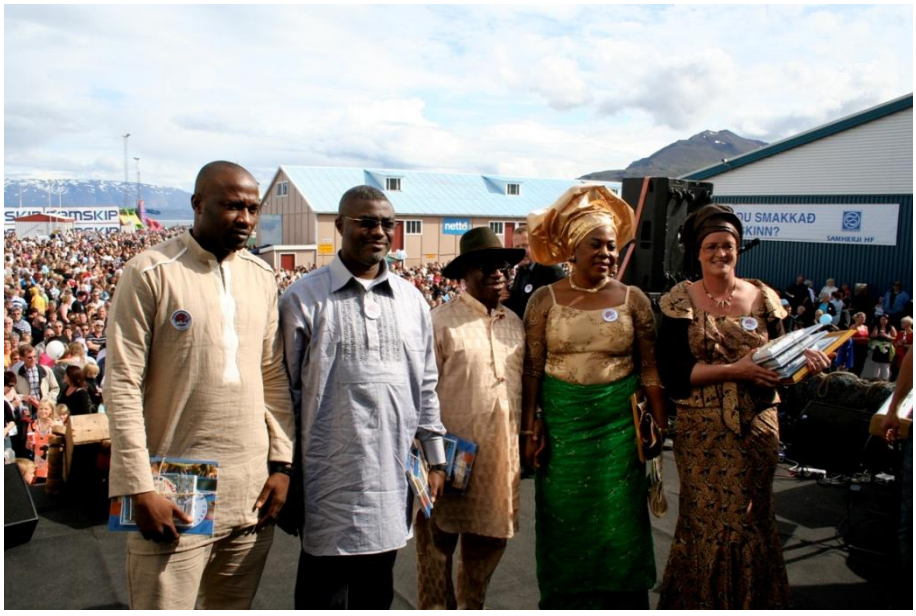
Repackaging fish into consumer packages in Nigeria.

Different dried fish products on display in a local Nigerian market.

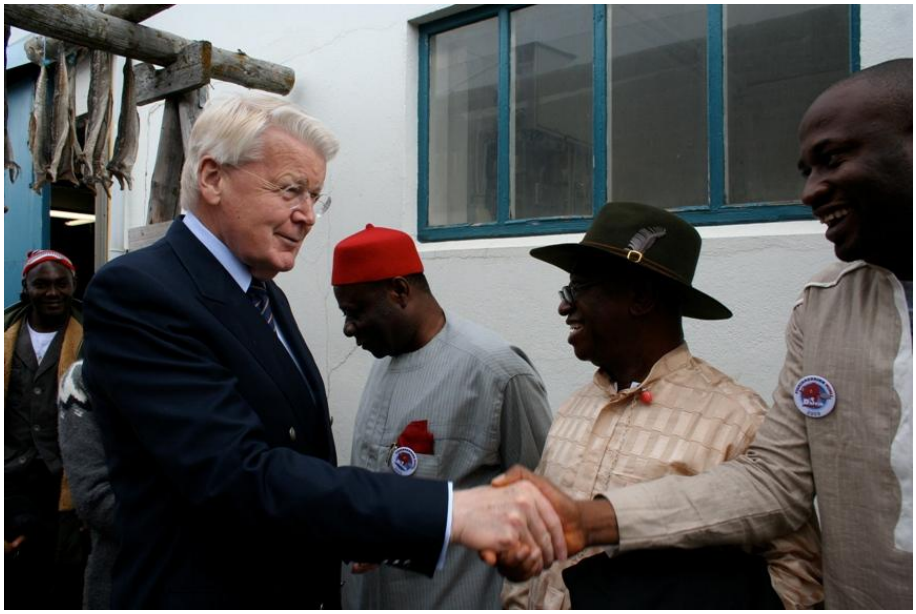


Dried fish displayed as part of 'Fish Day' celebration in Dalvík in northern Iceland. A homage to the Nigerian market is clearly a part of the festivities.

From the Fish Day celebration in Dalvík, Iceland.



Welcoming the Nigerian customers in Dalvík, Iceland.



President Ólafur Ragnar Grímsson greeting Nigerian fish merchants in Dalvík, Iceland.

Protein-rich leftovers of fish, useful as a fertilizer.

Appendix 2. Dried fish providers in Iceland

Most of the companies are also involved in other types of fish processing, and not all are using geothermal for their drying process. The listing is based on information from Promote Iceland (Islandsstofa.is), an agency which can provide more detailed contact information if needed.

Ice-Group Ltd.
Iðavöllum 7a, 230 Reykjanesbæ
✆+354 421 7041, +354 421 7042 Email: icegroup@icegroup.is Web: www.icegroup.is. Established: 1997 Personnel: 7. Description: Export of Seafoods, specialising in salted, frozen, fresh and dried fish heads and stockfish. Fresh fish fillets and whole around, flown in daily.

Salka-Norfish Ltd
Ráðhúsið, 620 Dalvík
✆+354 466 1875, +354 466 1650 Email: norfish@norfish.is Web: www.norfish.is Established: 1987 Personnel: 4 Description: Salka-Norfish Ltd. specializes in export of dried fish products to West-Africa with focus on Nigeria. We export all kinds of dried fish products, fish heads, cuts, cutlets, bones, stockfish etc. We are agents for Icelandic dried fish producers and we are the leading company in export of dried fish products sold from Iceland to Nigeria. Our trademark is NOR.

Samherji hf.
Glerárgötu 30, 600 Akureyri
✆+354 460 9000, +354 460 9099 Email: samherji@samherji.is Web: www.samherji.is Established: 1972 Personnel: 700. Description: Samherji is a company operating freezer trawlers and land-based processing plants for whitefish, pelagic fish, dried fish heads,fish meal and fish oil. Samherji is vertically integrated and exports its own production under the „ICE FRESH SEAFOOD“ brand.

Brim hf
Braedraborgarstigur 16, 101 Reykjavik, ✆+354 580 4200, brimhf@brimhf.is, www.brimhf.is

Fisco ehf.
Adalstraeti 6, 101 Reykjavík/Dalvegi 16a 201 Kópavogur

Gullfiskur ehf., harðfiskverkun
Eyrartröð 11, 220 Hafnarfjordur

Harðfiskverkunin Darri ehf.

ICECOD
P.O. Box 170, 172 Seltjarnarnesi, ✆+354 552 1862 ✆+354 898 1862, Icecod@simnet.is, www.icecod.com

Iceland Sea Products
Hafnargotu 60, 230 Reykjanesbae, ✆+354 421 6585, agust@isfoss.com, www. isfoss.com

Iceland Seafood International
Ltd., Kollunarklettsvegur 2, 104 Reykjavik, ✆+354 550 8000, is@is.is, www.is.is

Icelandic Export Center Ltd.,
Sidumula 34, 108 Reykjavik, ✆+354 588 7600, info@iec.is, www.iec.is Ifex

ÍSLENSKA umboðssalan hf.,
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Merlo Seafood
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References

Alþýðumaðurinn 22 August 1950. Allmörg saltfiskþurrkuknartæki eru nú í smíðum hjá Landssmiðjunni (p. 4).

Arason, Sigurjón, 2003. The Drying of Fish and Utilization of Geothermal Energy: The Icelandic Experience. *GHC Bulletin*, December 2003.

Árni Þór Bjarnason, 2011. Viðskipti í Nígeríu og Vestur-Afríku. Erindi. Sjávarútvegsráðstefnan 2011. http://www.sjavarutvegsradstefnan.is/files/Arni.pdf

Internationial Geothermal Association. http://www.geothermal-energy.org

Haustak. http://www.haustak.is

International Endeavours Corp, 2012. http://www.endeavorscorp.com/our_sector/green_technologies/geothermal/

Kumoro, Andri Cahyo, and Dedy Kristanto, 2003. Preliminary study on the utilizatio nof geothermal energy for drying of agricultural product. *International Geothermal Conference*, Reykjavík, Sept. 2003 (Session #14).

Kurlansky, Mark. *Cod : A Biography of the Fish that Changed the World*. New York: Walker, 1979.

Lund et al., 2010. John W. Lund, Derek H. Freeston, Tonya L. Boyd. Direct Utilization of Geothermal Energy 2010 Worldwide Review. *Proceedings*. *World Geothermal Congress 2010*. Bali, Indonesia, 25-29 April 2010.

Magnús Guðmundsson and Óli Þór Hilmarsson. Þurrverkun kindakjöts. Skýrsla til Framleiðnisjóðs landbúnaðarins. Janúar 2003.

Morgunblaðið 12 February 2007. Fiskúrgangi breytt í mat (p. 12).

Shaviklo et al., 2011. Gholam Reza Shaviklo, Gudjon Thorkelsson, Fereidon Rafipour and Sjofn Sigurgisladottir. Quality and storage stability of extruded puffed corn-fish snacks during 6-month storage at ambient temperature. Society of Chemical Industry, Wiley. http://onlinelibrary.wiley.com/doi/10.1002/jsfa.4261/abstract

Soriao, Rene, 1987. Copra and Fish-drying Using Low-Temperature Geothermal Energy. UNU Geothermal Training Programme, Reykjavik, Iceland.

Vísindavefur 2012. http://visindavefur.hi.is/svar.php?id=54563 Information on volume and value of 2010 exports to Nigeria.

Personal communication

Interviews with Mr. Ásgeir Benediktsson, Ms. Inga Jóna Friðgeirsdóttir (at Laugafiskur), Sighvatur Sigurðsson (Laugafiskur), Víkingur Halldórsson (Haustak) and Víkingur Þ. Víkingsson (Haustak) in March 2012.