ICELAND OCEAN CLUSTER

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100% ASIAN CARP

PREPARED AND PRESENTED BY

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SUMMARY

The group of fish species known in the US as Asian carp include several which are invasive. One of these species is the Silver Carp which has caused concern in the Great Lakes area because of the potential for competition with native species.

The task of the Iceland Ocean Cluster (IOC) was to develop a strategy with suggested actions, including steps to maximize the utilization of Silver Carp in the Great Lakes. The findings should serve as a roadmap into the future. The IOC's strategic partners in this project were the companies Marel, Curio, Haustak, Matís and Skaginn 3X. These partners all have worldwide recognition within their area of expertise.

The overall study on the Silver Carp gave positive results but this report emphasizes the need for further studies and testing.

Using newest processing technology, drying technology and a team of researchers regarding the quality of the Silver Carp's filet and byproducts, there are clear signs that the Silver Carp can create more value for the Great Lakes Community.

Using newest processing technology for fileting, gave very promising results. Based on throughput the payback time seems to be acceptable. This needs to be studied further and more information given about possible amount of the throughput and marketing and sales efforts.

All the options involve investment in equipment for starting new processing methods. Lowest cost would be setting up the fish silage production and highest cost is processing the fillets and fully utilize each fish caught.

Further studies and testing of the Silver Carp are needed to determine next steps. However, our study shows huge potentials for the Silver Carp if further collaboration is created among fish processors, the fish is processed efficiently and marketing efforts are increased. If the by-products of the Silver Carp are treated professionally, we also see various potentials for these byproducts to create value for the industry.

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INTRODUCTION

Asian Carp is an umbrella name used for various types of Carp. Asian Carps are invasive species in the Great Lakes. These species are Bighead Carp (Hypophthalmichthys nobilis), Silver Carp (Hypophthalmichthys molitrix), Black Carp (Mylopharyngodon piceus) and Grass Carp (Ctenopharyngodon idella).

The Silver Carp (amongst other types of Carp) were introduced to the U.S. in the 70's to control primarily algae, weed and parasite growth in aquatic farms, weeds in canal systems, and as one form of sewage treatment. Within ten years, it had escaped its confinement and spread to surrounding waters. They are thought to have lowered water quality and, of having harmed native fish communities such as native freshwater mussels and interfered with commercial and recreational fishing.

Bighead Carp and Silver Carp are closely related and have been known to crossbreed and produce viable, reproductive offspring. They are fast growing and prolific eaters that out-compete native fish and leave a trail of environmental destruction in their wake.

Silver Carps feed primarily on phytoplankton. They lack a true stomach which requires them to feed almost continuously. Silver Carps mature in 2 to 4 years and commonly weigh 20 pounds (9kg) but can reach a maximum size of more than 80 pounds (36kg) when older. Silver Carp can jump 9 feet (2.7m) when startled which causes hazard for anglers, boaters, and other recreational users. Asian Carps are not favored food fish in North America and, therefore, industrial end uses, and markets are likely to generate greater demand.

A considerable volume of Asian Carp is currently being exported from Illinois to China for human consumption, but transportation costs and logistics limit this approach and its ability to drive harvest pressure to control Carp population.

ALTERNATIVES FOR UTILIZING THE SILVER CARP INTESTINES

The objective of this chapter is to present results from a study on potential value creation options from the viscera / intestines of Silver Carp. Focus was especially awarded to identifying possible alternatives for utilizing the liver, viscera, and swim bladder into valuable products. The research was done by IOCs partner, Matís, an independent, governmentally owned, food and biotech R&D company headquartered in Iceland.

The initial desk study focused on previous literature and research regarding Asian Carp.

Few studies have reported on proximate composition of Asian Carps in the Illinois River. The fat content of whole Silver Carp was reported by Bowzer, J. et al. (2013) in the range of 3.9 – 7.4 % with variation by catch location and season, with higher fat content reported in the summer (see table 1).

		Seasons		
Species	Composition	Fall	Spring	Summer
Silver Carp	Moisture	74.9 ± 0.4 z	71.0 ± 0.4 y	69.2 ± 0.4 x
	Protein	14.8 ± 0.8 y	15.7 ± 0.7 z	16.3 ± 0.7 z
	Lipid	3.9 ± 1.1 y	6.1 ± 1.0 z	7.4 ± 1.0 z
	Ash	5.6 ± 0.6 z	6.0 ± 0.5 z	5.6 ± 0.5 y
Bighead Carp	Moisture	80.4 ± 0.8 z	78.5 ± 0.4 z	76.7 ± 0.3 y
	Protein	13.1 ± 1.8 zy	13.4 ± 0.9 y	15.5 ± 0.6 z
	Lipid	1.3 ± 1.5	2.0 ± 0.8	2.3 ± 0.5
	Ash	5.0 ± 1.3 z	4.5 ± 0.7 y	4.8 ± 0.5 y

Table 1:
Proximate composition (%) of Asian Carp harvested seasonally from the Illinois River (fall 2010-summer 2011) and pooled across all five harvest locations (Alton, La Grange, Peoria, Starved Rock, and Marseilles). Numeric labels indicate mean percent composition of the intact carcasses (i.e. wet matter basis); numbers may not add to 100% because of minor amounts of carbohydrate not analyzed and rounding errors. Letters indicate significant differences within species across seasons at $P < 0.05$. (Bowzer J. et al. 2013).

Buchtová and Ježek (2011) observed that the internal organs of farmed Silver Carp harvested in the fall had 3.5% fat content and the fatty acid composition was approximately 25% SFA, 47% MUFA and 17% PUFA similar to the fillets in PUFA content. Another study done on Silver Carp in Ohio River by Ferguson, CS. et al. (2020). They observed that the total offal had only 1.5% fat content and viscera of 3.1% fat content with PUFA approximately 16% of the fat in the offal and only 5% in the viscera. The Silver Carp was almost 4.5 times leaner than Silver Carp harvested in the summer.

Methods

Mass balance of the liver, viscera and swim bladder was done on five Silver Carps caught from the Illinois river. Livers and viscera from four Carps were pooled and analyzed for water (ISO 6496-1999) and fat content (AOCS Ba 3-38 (2017)). Utilization alternatives were then identified, based on the results of the analysis and expertise of Matís.

The study on intestines provides initial identification of utilization alternatives for liver, viscera, and swim bladders of Silver Carp. The proportions of liver and viscera of the whole fish that was analyzed for this report was 2.5 ± 0.6% and 4.9 ± 1.5% with a fat content of 3.1% and 7.5% respectively.

The viscera (including liver and roe) constitute approximately 7-8% of the net weight of the Silver Carp received with a fat content of 6.0 %. The oil from these raw materials contains PUFAs, including omega 3 fatty acids such as EPA and DHA, that can be utilized in health products and pet-food or feed for animals and farmed fish.

Results and next steps

Mass balance of the liver, viscera, and swim bladder of five Silver Carps (previously frozen) was made to determine what volumes could be available and what chemical properties these parts have. The results are shown in table 2, in terms of wet weight. The weight of the fish ranged from 1.0 – 2.5 kg (w/w).

	Proportion	Water content	Fat content	FFDM
Liver	2.5 ± 0.6 %	79.3 %	3.1 %	17.6 %
Viscera	4.9 ± 1.5 %	73.0 %	7.5 %	19.5%
Swim bladder	1.1 ± 0.2 %			
Internal organs	8.5 ± 1.5 %			

Table 2:
Mass balance (% weight of whole fish) of internal organs from 5 Silver Carps harvested from the Illinois River. Water and fat content were measured in pooled samples of liver and viscera. (FFDM = Fat free dry matter including protein and minerals)

Liver is approximately 2.5 % of the whole fish, with fat content of 3.1 %. Viscera was approximately 4.9 % of the whole fish with fat content of 7.5 %. Liver and viscera together would amount to 7.4% of the whole fish with approximately 75.2% water content and 6.0% fat content which is generally low compared to viscera and livers from some other species such as Atlantic cod which has approximately 40% of the liver as fats and 26.5% fat content in viscera.

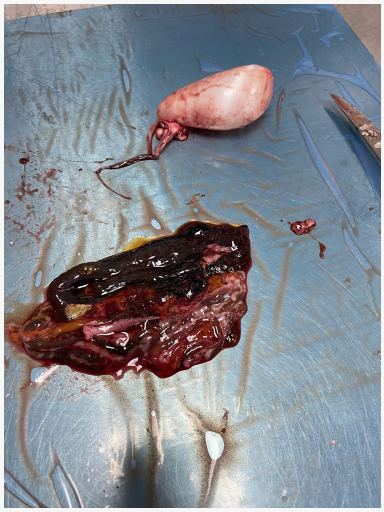
Among the simpler methods of utilizing viscera is to freeze it and then use as e.g. mink-feed, which has been common practice in many fish processing plants that are sourcing un-gutted fish. More technological methods, that provide higher margin, includes the protein plant that the Icelandic company Héðinn in cooperation with Matís developed. This equipment can utilize viscera/offal from fish; producing oils and fish meal. The protein plant takes up very little space and can be fit in a standard transportation container, making it possible to be placed in small fishing villages or on-board factory vessels (Jónsson and Viðarsson, 2016)1.

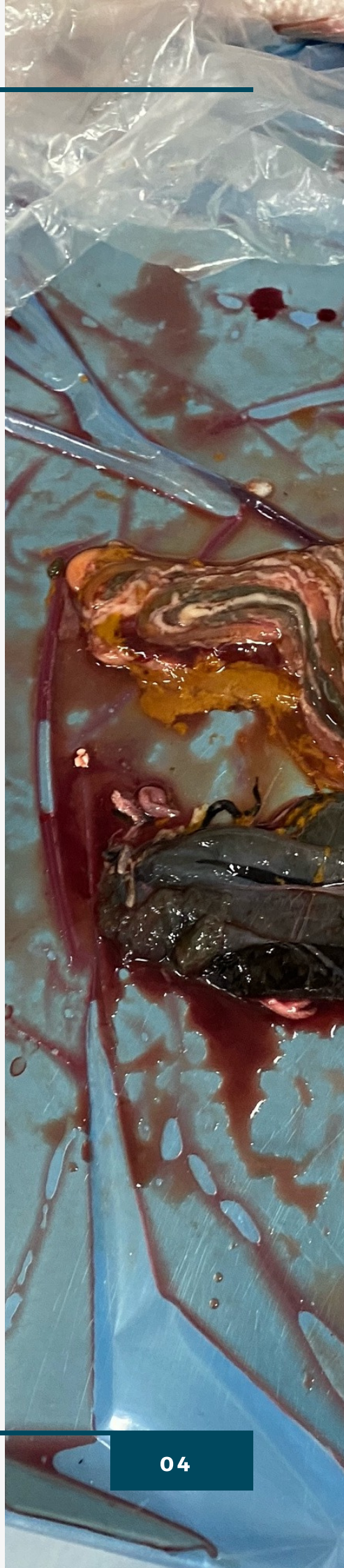
1 https://hedinn.com/fishmeal-processing/the-hpp-process/

The liver and viscera could be processed into fish meal and oil or processed into fish silage. Fish meal and oil production is highly dependent on volume since the investment and production cost is most likely high and a better alternative would be to process all rest raw material originating from Asian Carps in a specific location together to increase the capacity of the production. Producing fish silage has lower investment and production cost and can better preserve the rest raw material until further processing.

The greatest value option for the intestines seems to lie in the possible use of the fat content of the Silver Carp for fish oil of human consumption. Given the increased global demand for liver oil, there seems to be an opportunity to further study the potential of creating value from the fat content of the intestines of the Asian Carp.

Further studies are however needed to determine the possible market for this specific product and its profitability.





DRYING THE SILVER CARP

The objective of this chapter is to present results from a test regarding drying of the Silver Carp for possible exporting of the dried fish to markets where dried fish is a valuable and sought after product. Our partner in this test was the company Haustak, a fish drying company in Iceland.

Drying fish for preservation is an age-old practice in Iceland and a very efficient way of preserving food. Dried fish has a storage life of several years. On soaking, it regains the qualities of fresh fish, providing a tasty nutritional meal. The company Haustak in Iceland specializes in drying fish products for the Nigerian market. Nigeria is considered the biggest and most stable market for dried fish products but there are opportunities in Asia, especially for the Silver Carp head.

Methods

The full drying process takes few weeks and is done in several steps, both in and out of drying compartments. This makes the fish thoroughly and evenly dry.

The process is very sustainable as geothermal power is used for the dryers and after drying the parts are packed in eco-friendly hessian bags.

The Silver Carp was dried for a full seven days in drying compartments, but that is considered enough drying time to see initial results from the drying process.

The fish was gutted and split into head, bones, fillets, and slices. The parts were placed on a rack and placed into a drying compartment. The specific method containing temperature on Celsius will not be reported here.

Results and next steps

The Silver Carp dried successfully. The drying process creates a weight loss of approx. 80% ± 5% which is in line with drying of many other fish species from Iceland currently exported mainly to Nigerian markets.. Even though the drying process was short, the parts soaked up nicely and the fish gained approx. 65% ± 5% of its flesh back, especially the slices.

African markets have a high demand for dried fish and the
fish used for drying is usually caught on lines and not frozen before drying. A study of the possibility of exporting dried Silver Carp to Africa is needed; market response to dried Asian Carp and feasibility of setting up a drying plant in Illinois.

FILLETING THE SILVER CARP

About 12kg of Silver Carp were used for testing at the company Curio in Iceland. Curio is a subsidiary of Marel which is one of the largest suppliers of fish processing technology in the world. The aim was to see if a modern filleting machine, probably one of the most advanced in the world, could fillet the Silver Carp more efficiently than the methods currently used, increase the yield from hand filleters and get as much bone away as possible.

The Silver Carp used for testing was rather small compared to average size of the fish.

Methods

Whole gutted fish was thawed and de-headed on Curio C-3027 and filleted with Curio machine C-2011 filleting. We manually pre-trimmed the belly on one fish so it would sit better in the machine. After adjustments, this was not needed.

Results and next steps

The fillets came out nicely, most of the bone was cut away and the fat line was off the fillets.

After three attempts the testing was successful with minor adjustments on Curio C-2011 filleter. Prior to filleting, the Silver Carp was de-headed on Curio C-3027.

The results were promising and based on throughput the payback time would be acceptable. This needs to be studied further and more information given about possible amount of the throughput and marketing and sales efforts.

Full weight kg	Head kg	Spine kg	Fillet skin on kg	Fillet skinless kg	Tail kg	Head %	Fillet %	Fillet skinless	Comments
1350	435	175	740			32%	55%		
1350	680		670			50%	50%		Not correct support in machine
1405	555	820			30	40%	0%		
1445	555	890				38%	0%		
1545	565	300	680	530		37%	44%	34%	Very nice fillets
1630	640	365	625			39%	38%		Pre-trimmed belly
1775	780	995				44%	0%		
Average numbers									
1500	*601*	*591*	*679*	*530*	*30*	*40%*	*45%*	*35%*	

FILLETING THE SILVER CARP

MINCING THE SILVER CARP

Most parts of the Silver Carp can be used for mince. Fillets with or without skin, skin strips and trimmings, and whole main bones. Due to COVID19, this study did not include a hands on testing of Silver Carp for mincing. Generally speaking, fillet trimmings are especially good for mincing. The Silver Carp has a very sharp pinkish fat line that is not ideal for minced fish. It gives the mince a different color that is not favorable for consumers. The fat line should not be placed with the trimmings for mincing.

Next steps
Our recommendation would be to test the mincing solution with tech solutions from Skaginn3X, Icelandic processing tech company. A RevoPortioner from Marel could then form the minced fish into the preferred shape and/or size.

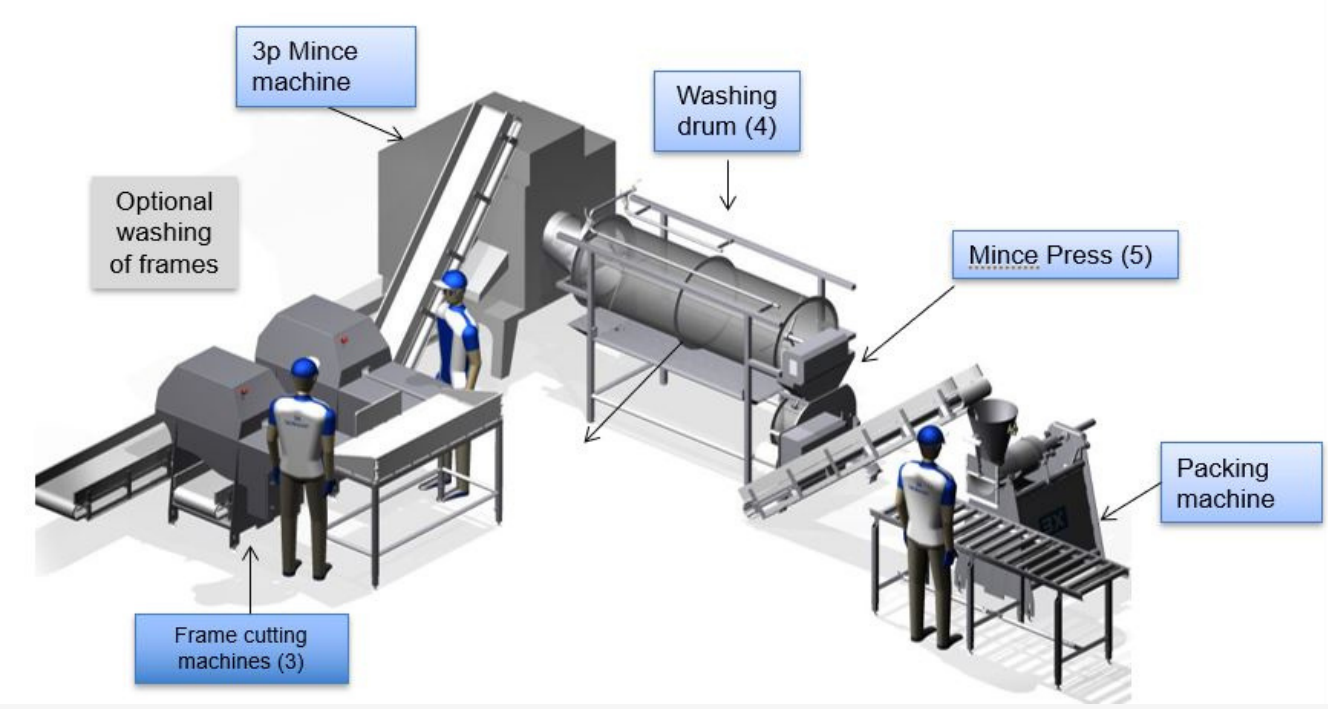
These are some of the benefits from Mincing solutions:
- Material savings:

Mince from machine fillets frames can be up to 28% of the frame's weight.
- Product quality:

The mince quality is increased by washing and pressing it by best practice.
- Economic:

Producing mince from frames will increase revenue and reduce waste.
- Flexible:

The water content of the mince can be easily adjusted.



POSSIBLE SILVER CARP BY-PRODUCT UTILIZATION

Fishmeal and oil processing

Asian Carp has been processed into fertilizers, but it may be possible to target higher value products for animal feeds industry such as aquaculture feeds. Asian Carp meal has several advantages over other alternative feedstuffs in aquafeed production because of its similarity to traditional, marine-origin fish meals that are considered ideal proteins in many ways. Ferguson et al. (2020) observed that the internal organs contain high amounts of minerals such as iron (1320 mg/100g), manganese (103 mg/100g), copper (2 mg/100g) and zinc (9 mg/100g).

The market price for fish meal of any origin is at close to 1,500 USD/ton and the market price for fish oil is close to 2,300 USD/ton, as shown in figure 1 (FAO, 2020).

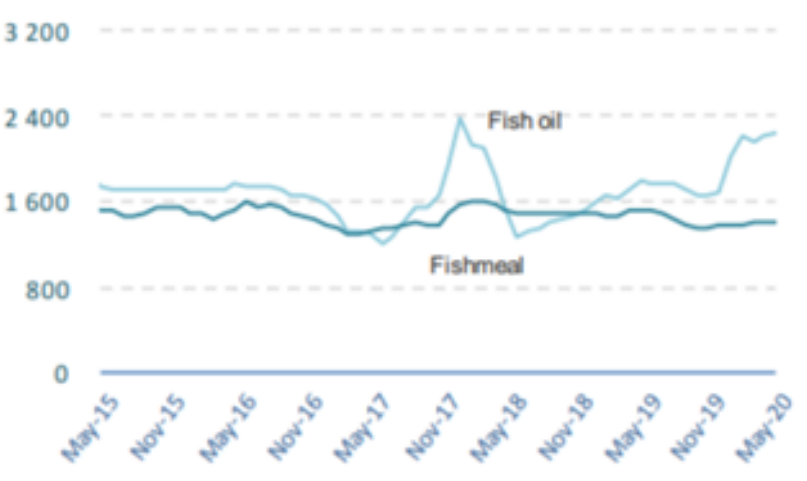


Figure 1: Average prices of fish oil and fish meal in Europe USD/ton (source: Oil World/FAO)

Assuming 1,000 tons of whole Silver Carp would be processed, the viscera and liver would be 74 tons, of rest raw material (RRM) processed further for fish oil the amount of crude fish oil achieved would be approximately 4.44 tons with a revenue of 10,200 USD.

Combining fishmeal and fish oil production through small production plant similar to that set up in Héðinn would give approximately 2.9 tons of oil and 17.4 tons of fishmeal, assuming fishmeal has a fat content of 5% and the fat free dry material (FFDM) of Silver Carp is 19%. The revenue of such a fishmeal and oil plant would be estimated 32,600 USD for 1,000 tons of whole Silver Carp with 74 tons of RRM processed (see tables 3 and 4).

	Water	Fat	FFDM
Liver and viscera	75%	6%	19%
Fishmeal	10%	9%	81%
Fish oil		100%	

Table 3 - Chemical composition of liver and viscera from Silver Carp and traditional fishmeal and oil

	High degree fishmeal plant
Whole Silver carp (ton)	1,000
Livers and viscera (ton)	74
Fish meal (ton)	17.36
Crude fish oil (ton)	2.88
Revenue	$ 32,656

Table 4 - Revenue of high degree fishmeal production of 1,000 tons of whole Silver Carp

Such a heavy processing with high investment and production costs is highly dependent on volume of material. Depending on how the Silver Carp is processed, whether it is sold headed and gutted or filleted, it would be more feasible to process all rest raw material originating from Asian Carps to increase the production capacity and revenue.

Fish silage

Fish silage and fish protein hydrolysate (FPH), which may be described as a liquid product made from fish or parts of fish, like viscera, after addition of acid, such as formic acid. Acid and enzymes are used to hydrolyze and brake down organic raw material into simpler components. Fish waste, more specifically fish viscera contains enzymes that are present in the raw material mixture, so the addition of industrial enzymes is not always needed. Production of silage limits the growth of spoilage bacteria and the product has an increased shelf life and can be processed further in to fish protein hydrolysate, fish meal or oil, or for the processing of fertilizers on fields and in the horticultural industry (Jónsson and Viðarsson, 2016).

It is challenging to estimate the revenue of silage production since there are uncertainties about the value of silage which depends on protein and fat content. It is common practice in the fishmeal industry that the fishmeal factory will buy the silage for 65% of the final end product value. Looking at the estimates of a high degree fishmeal plant above the estimated value of the silage production for the same material would be 21,226 USD.

Estimating the revenue of FPH is also difficult since the prices of FPH have enormous range, depending on quality. In Europe the value of FPH is on average around 3,600 USD/ton. If the fish silage would be processed further into FPH and oil it could be estimated that 74 tons of livers and viscera would give 15.6 tons of FPH and 3.5 tons of crude oil for a total revenue of 65,000 USD (tables 5 and 6)

	Water	Fat	FFDM
Liver and viscera	75%	6%	19%
Fish protein hydrolysate	1-8%	<5%	85-90%
Fish oil		100%	

Table 5 - Chemical composition of liver and viscera from Silver Carp and traditional fishmeal and oil

	High degree hydrolysis
Whole Silver carp (ton)	1000
Livers and viscera (ton)	74
FPH (ton)	15.62
Crude fish oil (ton)	3.82
Revenue	$ 65,000

Table 6 - Revenue of high degree fishmeal production of 1,000 tons of whole Silver Carp

The investment costs for fully processing the silage are high, but the revenue can be well worth it. A more detailed study on the quality of the raw material and products is needed to give a better estimate on the revenue since the price of FPH can range from 1,000 – 6,000 EUR depending on quality.

Swim bladder

Dried swim bladders are popular products in Asia and in 2013 the retail price of swim bladders from Atlantic cod in China was over 100,000 ISK/kg or 775 USD/kg, if the product met consumer demands.
This product is mainly used in soups or fried. The swim bladder is both salted and dried and the process can be labor intensive (Jónsson, Á. and Viðarsson, JR. 2016). The swim bladder of Silver Carp was approximately 1.1% of the whole fish (wet weight) and could create value from material that would otherwise be discarded.

The swim bladder has an opportunity of being processed further into either dried swim bladder for human consumption or for collagen products used in the health industry. More studies on collagen yield from Silver Carps is needed to estimate what revenue that can be achieved.

Collagen

Collagen can be produced from different sources such as fish skins, bones and swim bladders. Utilization of fish collagen are globally of interest to the food processing industry as well as the health industry. The process however requires a fairly large investment in development and equipment. Dasong Liu et al. (2011) extracted collagen from swim bladders of Bighead Carps with an extraction yield of approximately 14% (wet weight).

The test results for utilizing of by-products are to be considered as an initial identification of utilization alternatives. Further analysis on them is needed to determine the applicability of the alternatives identified for the liver, viscera, and swim bladder.

There are researches from Nofima and Sintef that indicate that the Silver Carp is not viable for food powder even though the nutritional value is there. The indicated problem is the smell and taste, especially after storage. It requires extensive investments to create this without the knowledge or certainty that the market is ready to pay the price needed to make this a sustainable industry and ROI for investors. Generally, it is considered a difficult process to create nutritional powder from fish for human consumption in the quantity needed.

CONCLUSION

The overall study on the Silver Carp gave very interesting results. The Silver Carp has a nice white flesh and a taste like whitefish species such as haddock and cod, but its bone structure is tricky and therefore the fillets, if not processed correctly, will not go well with American consumers.

One of the challenges ahead are to introduce the Silver Carp as an option for American consumers. There is a long way to go but the seafood industry has seen a tremendous success of species that not long ago were not processed for human consumption. On average, Americans consumed 16.1 pounds (7,3kg) of seafood in 2018 which is quite low compared to the 49 pounds (22.3kg) global consumption according to the European Union's Science Hub. Fish consumption in America has however been growing for the past decade and there are opportunities to increase the consumption with more variety of seafood options. Especially fish that is caught locally and not imported.

To strengthen the industry in the Great Lakes and maximize revenues of Asian Carp, an increased co-operation between the processing plants is very much needed. A State of the art processing equipment is needed to maximize utilization, through-put and revenues. This can be done in one location in an industry park where all Asian Carp that is caught is transported to. Allowing highest quality processing machines from numerous manufacturers to be used.

There are numerous options regarding the processing of the Silver Carp which should be studied further.

Technology is available for blooding and gutting, separating gut into tubs, de-heading and filleting, drying heads, bones and swim bladder. Drying the whole fish into pieces as was done in the testing at Haustak is one very interesting option as there are markets for these dried products. In China alone, approx. 26.1kg of fish is consumed per capita annually.

Also, the liver and viscera can be made into fish meal. Drying and fishmeal should be done in same location to lower production cost.

Further studies and tests need to be done regarding the markets for each product: Heads, bones, and swim bladder can be sold to China and Africa, especially Nigeria. Frozen fillets for domestic supermarkets and restaurants. Liver and viscera to domestic fish meal processing.

As can be seen from above, there are clear signs that Silver Carp (Asian Carp) can create value for the Great Lakes Community. All options involve cost for starting new processing methods. Lowest cost would be setting up the fish silage production and highest cost is processing the fillets and fully utilize each fish caught.

Further studies and testing of the Silver Carp are needed to determine next steps. However, our study shows huge potentials for the Silver Carp if further collaboration is created among fish processors and the fish is processed efficiently. If the by-products of the Silver Carp are treated professionally, we also see various potentials for these byproducts to create value for the industry.

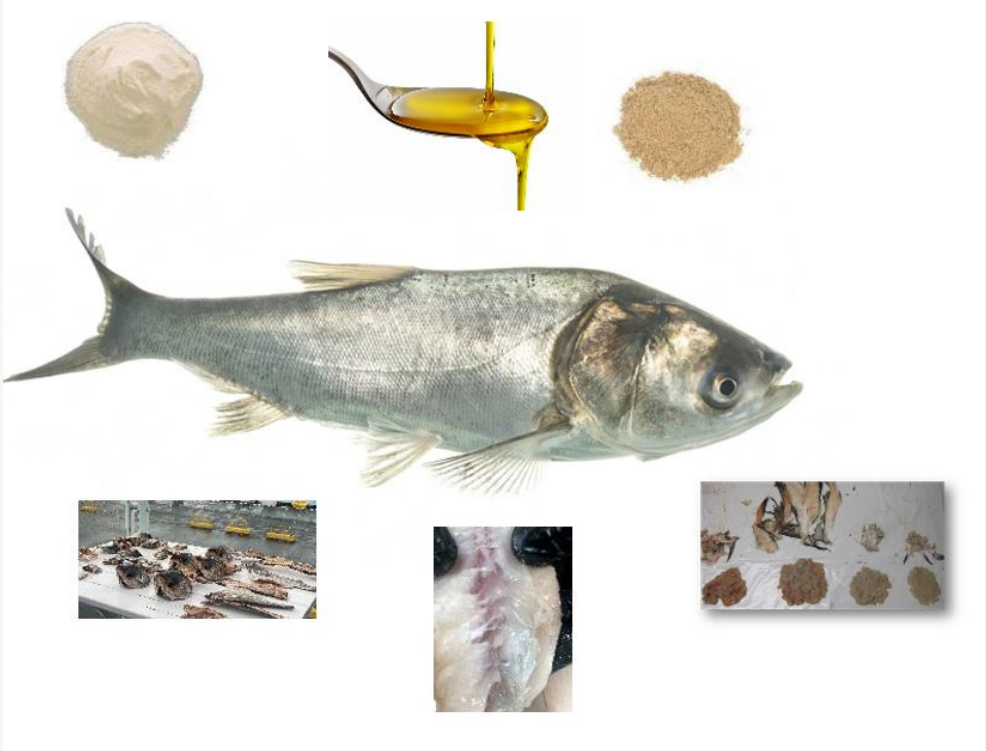
NEXT STEPS

Our recommendation for the next steps are the following:
A drying of the Silver Carp in larger amounts would be feasible. 2-3 MT of the Silver Carp would mean 400-600 kg of products. These dried products would be tested in the Nigerian markets. Also, a feasibility study regarding the establishment of a drying plant in Illinois would be preferable.

A study would be needed where the feasibility of a new fileting machine is evaluated. How much throughput is needed to make profit; what might be the estimated price of the Silver Carp fillet if processed in the way which our study have shown possible with newest technology?

A testing of mincing and forming using Icelandic technology would be very beneficial for the study. Due to COVID19 this was not possible but we assume the opportunity may arise later this year. The amount needed would be 100kg.

Combining fishmeal and fish oil production through small production plant could be feasible but further economic study is needed.



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