New Opportunities for Seafood Processing Waste

Appendix 13: Small Scale Dehydration of Air Bladders from Different Species Of Fish To Produce Fish Maw

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1. Introduction and Background

As part of the project FRDC 2013/711.40 New Opportunities for Seafood Waste, a seafood company Dried Seafood Corporation approached Curtin University requesting some trials on drying swim bladders. As a result of series of experiments were conducted on barramundi swim bladders to optimise drying methodologies. These result are available in an aligned report Barramundi Swim Bladders: Optimisation of Sanitising, Cleaning and Drying of Air Bladders for Human Consumption.

Following discussions with the various industry partners it was decided that the next step was to dry swim bladders from a range of species and compare with commercially available products. The bladders were to be assessed as per the "quality" parameters" defined in the previous report and reproduced below.

1. Size: The bigger the fish is, the bigger the stomach is thus the higher the price is commanded. Retail customers buy large fish maw and smaller fish maw is purchased by restaurant trade. Size was important, with thicker and larger maws more premium.
2. Source Species: The quality of fish maw also depends on the type of fish. Fish such as sturgeon, hake, conger-pike, croaker and carp get high price for their fish maws. The reason is that these fishes have large and developed air bladders
3. Thickness (related to gender): Male fish's air bladder is thicker and thus commands higher price. Fish maw from males has a thicker body and is soft and smooth and does not easily dissolve in mouth. The female fish maw is thinner and tender to bite
4. Colour: Good fish maw, has to be yellow. The richer the colors are, the more it is able to maintain texture through an extended period of cooking.
5. Age: the older the fish maw is, the better it is. Reason being, it has less oil and less fishy taste
6. Aroma: Aroma is not an influential factor with dried fish maw, in comparison to other dried seafood.
7. Texture: Cooked fish maw should be soft and thick.

2. Barramundi (Different Harvest Areas)

2.1 Aim

Assess the quality parameters of dried whole farmed barramundi air bladders from different harvest areas in Australia.

Whole frozen farmed barramundi air bladders were supplied by Sealanes and Dried Seafood Corporation. The Sealanes air bladders were from an aquaculture facility whereas the Dried Seafood Corporation samples were from wild harvest.

Two trials were conducted, Trial 1 without manual internal cleaning, and Trial 2 with manual internal cleaning.

2.2 Trial 1

2.2.1 Methods

Thawed air bladders (uncleaned) were sanitised for 30minutes in a 50ppm Chlorine Dioxide solution. Sanitised air bladders were pat dry with a paper towel and weighed. Air bladders were placed on a tray and dried for 17-22 hours in the Sunbeam Dehydrator at 35°C. Dried air bladders were weighed to determine the yield.

Dried barramundi air bladders from each harvest area were sent to a NATA accredited laboratory after 1 month of ambient storage to measure the TPC.

2.2.2 Results and Discussion

There were observable differences between the air bladders from different suppliers. The Sealanes air bladders were longer and thicker than the Dried Seafood Co air bladders, as shown in Figure 1. The average weight of the initial and dried weight of the air bladders was observably higher for the Sealanes air bladders (Table 1). The air bladders were dried with internal membranes inside still. Yellow gall stains were observed in air bladders from both suppliers.

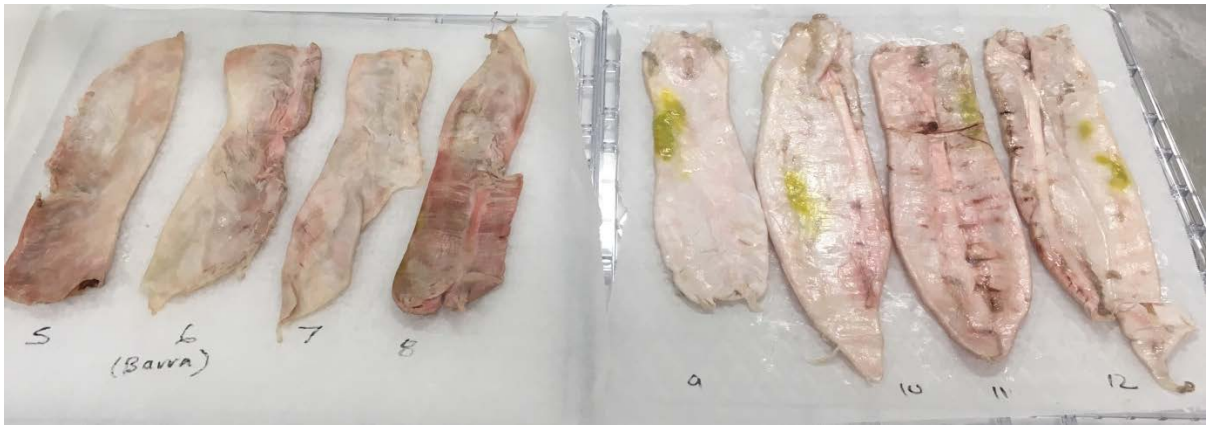

Figure 1 Barramundi air bladders from Sealanes (left 4) and Dried Seafood Co (right 4)

Table 1 Yields for the dried barramundi air bladders

Source	# Samples	Initial Weight after sanitising (g)	Dried weight (g)	% yield	Drying time (hours)
Dried Seafood Co	7	31.25	12.58	40%	17
Sealanes	4	51.75	21.51	41.6%	22

The larger size of the Sealanes air bladders meant that they required a longer drying time than the Dried Seafood Co samples at 22 hours and 17 hours, respectively. The dried product yield was similar between the different samples between 40-41.6%.

After the drying process, both samples of air bladders were not visually appealing (Figures 2 and 3). The dried air bladders become transparent upon drying. The presence of blood capillaries lining the internal wall and membranes gave the air bladders a 'dirty' appearance. There were also small amounts of fat still present on the outer membrane after drying which imparted a rancid smell on the final product. The presence of fat would also leave smears on the packaging. The removal of the internal membrane may enhance the appearance of the final product. The gall stains as still visible of the dried air bladders from both suppliers.

Figure 2 Dried barramundi air bladders supplied by Sealanes

Figure 3 Dried barramundi air bladders supplied by Dried Seafood Co

After one month ambient storage, the TPC for both samples were acceptable (Table 2). The Sealanes air bladder had a higher TPC. Microbiological analysis was only conducted on one sample from each supplier.

Table 2 Microbiology results on the dried air bladders after one month ambient storage

Sample	TPC (cfu/g)
Sealanes	85000
Dried Seafood Co	420

2.2.3 Summary

The barramundi air bladders from Sealanes were much bigger in size than the Dried Seafood Co. There are several factors such as size and harvest area that could have an influence on this. The air bladders from both suppliers dried in less than 22 hours, however the dried samples are visually unappealing as the colour is a dark red/ caramel marbled colour. The dark red colour is due to the presence of the internal membrane and gives the 'dirty' appearance. Further trial to be conducted on drying the same barramundi air bladders, with the internal membranes removed prior to drying (Trial 2: Section 2.3).

2.3 Trial 2

2.3.1 Methods

Thawed air bladders were sanitised for 30minutes in a 50ppm Chlorine Dioxide solution. Sanitised air bladders were pat dry with a paper towel and weighed. Using gloves, the internal membrane and any remaining out membrane was carefully removed from the air bladder before recording the weight again. Cleaned air bladders were placed on a tray and dried for 15.5 hours in the Sunbeam Dehydrator at 35°C. Dried air bladder weight was recorded to determine the yield from initial and cleaned air bladders.

2.3.2 Results and Discussion

When attempting to clean the air bladders, there was a small wall between the middle of the dorsal end of the air bladder. This wall only ran for ~2cm, before the two sides of the air bladder join to become one large cavity. The wall had to be cut to enable manual cleaning. The material lining the internal wall of the air bladder was very thin and varied in colour between each fish, ranging from creamy white to a dark red-brown colour. It was easily removed. The Sealanes air bladders also had some fat membrane on the exterior of the bladder which was removed. The Sealanes barramundi air bladders were thicker, heavier and larger than the air bladders provided by Dried Seafood Co, as demonstrated by the larger initial weight in Table 3.

Table 3 Dried airbladder yields from the initial and cleaned weight.

Sample #	Source	Initial Weight (g)	Cleaned weight (g)	Dried weight (g)	% yield – from initial weight	% yield- from cleaned weight
1	Sealanes	55.66	35.82	23.02	41.4%	64.3%
2	Sealanes	51.75	36.61	21.51	41.6%	58.8%
Average					41.5%	61.5%
3	Dried Seafood Co	29.97	34.27	11.71	39.1%	34.2%
4	Dried Seafood Co	29.55	34.37	11.18	37.8%	32.5%
5	Dried Seafood Co	28.75	26.25	10.8	37.6%	41.1%
Average					38.2%	35.9%

The yield from both the initial and cleaned weight was higher for the air bladders supplied by Sealanes. The yield from the initial weight was 41.5%, whereas the average yield from the Dried Seafood Corp air bladders was 38.2%.

The gall stain was noted in all samples prior to drying with a distinct bright yellow stain (Figure 4).

Figure 4 Cleaned barramundi air bladders before drying. Sealanes (1,2) and Dried Seafood Co (3-5)

When the air bladders were dried, the gall stains had become a darker yellow-green colour (Figure 5). The gall stains, in contrast to the red-tan colour of the air bladder itself once dried, were not as visible.

Figure 5 Dried barramundi air bladders. Sealanes (2 left) and Dried Seafood Co (3 right)

In the cleaned samples there was less fat exudation than in Trial 1 (2.2). The colour and appearance of the cleaned dried air bladders are visually appealing and look clean in comparison to the uncleaned samples produced in Trial 1. Gall stains were still present after drying and require attention to wasy to decrease (eg harvest strategies).

2.4 Summary

The whole barramundi air bladders that were cleaned to remove the membranes and dried was visually more appealing than the air bladders than whole barramundi air bladders that contained the membranes (Trial 4). Although the appearance is more acceptable, it is important to show these samples to the target market to gather their thoughts to gage if there would be interest if the product was commercialised and how it rates against dried air bladders currently available on the market.

3. Barramundi, Mulloway and Jewfish

3.1 Aim

Dry air bladders from different species of fish and observe the differences between each species.

3.2 Materials

Frozen air bladders from the following species of fish were supplied for this trial:

- 2x Farmed Barramundi cleaned and split air bladder from ~ 5kg farmed fish (Dried Seafood Co)
- 2x Farmed Barramundi whole, cleaned air bladder from ~5kg farmed fish (Dried Seafood Co)
- 1x Jewfish whole, cleaned air bladder from an 8kg fish (Dried Seafood Co)
- 2x Mulloway whole, cleaned air bladder (Norwest Seafoods)

Results are separated into the results from the different species (3.4.1) and then the impact of splitting the barramundi air bladder rather than keeping it intact (3.4.2)

3.3 Methods

The frozen air bladders were thawed in refrigerated conditions 24 hours prior.

Air bladder preparation

1. Place whole air bladders in a 50ppm Chlorine Dioxide solution for 30 minutes.
2. Samples removed from solution and pat dry with paper towels. Weight recorded.
3. Mulloway and jewfish whole air bladders were split and cleaned. Dissecting scissors were used to cut through the centre of the air bladder and the external and internal membrane of the air bladder gently removed with hands. Weight of the cleaned air bladders recorded.
4. Samples were laid flat on drying trays and dried in the Sunbeam Dehydrator at 35°C for 17 hours.
5. The dried sample weight was recorded.

Yield

The weight of the air bladder will be recorded at different stages of the process to calculate yield:

- Initial wet weight
- After cleaning (sanitising and membrane removal)
- After drying

Visual observations

The raw whole and dried air bladders were assessed on the absence and presence of the gall bladder stain, thickness and colour.

3.4 Results and Discussion

After 16:15 hours, the air bladders had all completely dried and were removed from the dehydrator.

3.4.1 Different species

The raw whole air bladders from the different species were similar in shape (long tube with opening at one end) but differed in size and thickness. The mulloway air bladder was much longer and wider in shape,

when compared to the smaller barramundi air bladder. Thickness was similar between barramundi ad mulloway. The jewfish air bladder was slightly thicker than the other samples and was shorter than the mulloway. The size of the air bladders will vary based on the size of the fish.

The internal membrane inside the mulloway air bladder was a maroon colour and had a strong fishy odour. The membrane inside the jewfish was a bright pink/red colour. The contents that were manually removed from the outer and inner surface of all air bladders include the capillaries lining the inside of the air bladder and fatty membrane (Figure 6). Most of the membrane was easy to remove, but care must be taken as some parts of the membrane tightly adhered to the air bladder. The colour and odour of the internal membrane of the air bladders of the different species will be influenced by factors such as post-harvest handling.

The whole raw air bladders of all species had noticeable gall stains, however the stains were more obvious and brighter on the barramundi air bladder as shown in Figure 7 and Figure 8. After drying, the gall stains on all air bladders had changed to a dull green colour, with varying darkness in the different species. The dried mulloway air bladder gall stain was not noticeable, whereas the stain on the dried barramundi was obvious (Figure 9, Figure 10). The presence and size of the gall stain on air bladders in each species will be dependent on several factors including pre harvest treatment.

Figure 7 Air bladders before drying. From left to right: jewfish, barramundi and mulloway

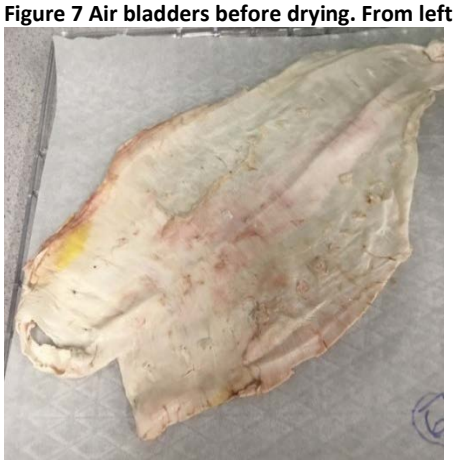

Figure 8 Split and cleaned mulloway air bladder prior to drying

Species	Raw- whole	Raw split – membrane attached	Raw split and cleaned (membrane removed)
Jewfish			
Mulloway			
Barramundi			

Figure 6 Appearance of air bladders from different species of fish in different raw format

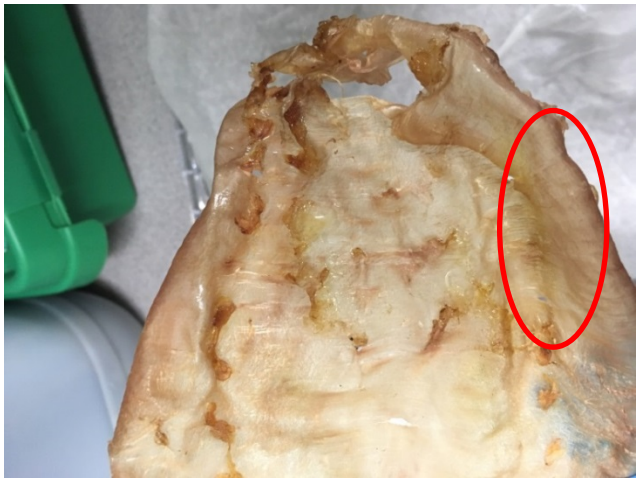

Figure 9 Mulloway air bladder, with gall stain not as visible when dried (circled)

Figure 10 Dried barramundi air bladder with gall stain circled.

The final product yield of the split and cleaned air bladders was highest for the barramundi, followed by the jewfish and mulloway, as shown in Table 4. The barramundi air bladders were supplied split and clean, therefore the yield from the wet weight could not be determined. The wet weight yield was 32% for the jewfish sample and an average of 25.1% for the mulloway. This is a small sample size and more trials should be conducted to determine the final product yield. The lower wet weight yield for the mulloway could be due to the presence of more membrane initially. The lower cleaned weight yield when compare to barramundi could be attributed to:

- the increased moisture content of the mulloway and jewfish air bladders
- moisture loss that could have occurred during the freezer storage of the cleaned and split barramundi air bladder which would have dripped off during thawing.

Table 4 Dried air bladder yields for split and cleaned air bladders of different species

Sample	Species	Initial wet weight(g)	Weight-cleaned (g)	Dried weight(g)	Membrane wt (%) (g)	Yield -wet weight (%)	Yield-cleaned(%)
1	Jewfish	67.5	58.8	21.6	13%	32%	36.7%
2	Barramundi	n/a	61.1	25	n/a	n/a	40.9%
3	Barramundi	n/a	38	15.5	n/a	n/a	40.8%
4	Mulloway	94.9	71	22.9	25%	24.1%	32.3%
5	Mulloway	100.2	81.2	26.3	19%	26.2%	32.4%

There was fat exuding from the dried mulloway air bladders which gave it a slightly rancid odour. There was no fat exudation noted on the dried barramundi and jewfish air bladders. The dried mulloway and jewfish air bladders were a light caramel colour with a slight red tinge (Figure 11). The dried barramundi air bladder was a straw cream colour with a slight pink tinge, comparatively lighter than the other samples. The thickness of the air bladders from the different species was comparable.

Figure 11 Air bladders after drying at 35C for 16.15 hours. From left to right: jewfish, barramundi and mulloway

3.4.2 Whole vs split barramundi air bladders

The colour of the dried whole air bladders was a darker caramel/pink colour in comparison to the split air bladder which was light cream colour with a pale pink tinge (Figure 12). The gall stain on the whole air bladder is not visible after drying, whereas the split air bladder gall stain still stands out (Figure 13). Although the gall stain is not visible after drying on the whole sample, further trials would need to be conducted to see whether this stain will be noticeable when cooked. The dried whole air bladder was also slightly thicker and more compact as it is still folded over. It dried relatively flat which could be advantageous in regards to product packaging if commercialised.

Figure 2 Whole cleaned air bladder before drying

Figure 12 Dried barramundi air bladder whole (left) and split (right)

The yield from the whole and split treatments was similar at 39.25% and 40.85%, respectively (Table 5). The average moisture loss between the samples was ~60% during drying, over half the initial weight. The drying of the air bladders appeared even on both samples.

Table 5 Dried product yields from whole and split barramundi air bladders

Sample	Treatment	Initial weight (cleaned) (g)	Dried weight (g)	Moisture Loss (%)	Yield (%)	Average Yield (%)
1	Whole	33.1	13.7	58.6%	41.4%	39.25%
2	Whole	27.8	10.3	62.9%	37.1%	

3	Split	38	15.5	59.2%	40.8%	40.85%
4	Split	61.1	25	59.1%	40.9%	

3.5 Summary

The different species of air bladders assessed in this trial did vary in size and shape. The split dried air bladders are similar in thickness between the species, with a difference noted in the colour after drying. The drying of the air bladders whole produced samples that were thicker, a nice caramel/red colour and would be easier to package due to the smaller size. The gall stain is not visible after drying of the whole air bladders, although further investigation is required to determine the effect of cooking on the visibility of the gall stain in the future.

Potential absence of the gall stain and proper removal of the fatty membrane are key factors to maximise the dried product quality. More focus on the pre and post-harvest techniques for the fish to retrieve the air bladder is required, noting that currently, air bladders are a waste product from the fishing industry and the harvest techniques currently used are aimed at maximising fish quality for consumption.

4. Wild caught ocean catfish air bladder

4.1 Background

Wild caught catfish inhabit the Arafura in the Gulf of Carpentaria. The fish is an underutilised species due to the name association with fresh water catfish. Sea catfish can range in size from 2-5kg each. The wild caught catfish is similar to the cobbler but cannot be called ocean cobbler. The fish contains a small but thick air bladder. With the high international demand for dried air bladders in Asia, with dried mulloway airbladder fetching $300/kg wet weight. In previous trials conducted, the yield is between 20-35% from wet weight. The current market value of catfish air bladder is $5-6/kg wet weight. With its unique shape and thickness, there could be market potential. The objective of this trial is to assess the effects of dehydration on the catfish airbladders and determine if the product could attract market interest in Asia. Realistically, the market value of the dried catfish bladder would have to be at least $30/kg wet weight in order for commercial viability.

4.2 Aim

To determine the yield and physical properties of dried wild caught catfish.

4.3 Methods

Drying the air bladders

Frozen wild caught ocean catfish air bladders were supplied by Westmore Seafood. The air bladders were thawed overnight at 4°C. The thawed air bladders were sanitised in a 50ppm Chlorine Dioxide solution for 30 minutes. The excess moisture was removed with a paper towel. The weight of each air bladder was recorded. Two air bladders were cleaned as prescribed below for each treatments:

- Whole: the outer membrane was removed from the air bladder manually
- Whole and clean: the outer and inner membrane of the air bladder was removed manually
- Clean and split: outer and inner membrane of the air bladder removed manually before using dissection scissors to cut through the centre of the air bladder.

The weight of the air bladders and membrane removed was recorded for each sample. The air bladders were laid flat on drying trays and dried in the Sunbeam Dehydrator at 35°C for 20-27.5 hours, until dry. The dried weight of the air bladders was recorded.

Yield

The weight of the air bladder will be recorded at different stages of the process to calculate yield:

- Initial wet weight
- After cleaning (sanitising and membrane removal)
- After drying

Microbiology

A dried clean and split catfish airbladder was sent to a NATA accredited laboratory after 2 months of ambient storage.

4.4 Results and Discussion

The catfish airbladders are circular in shape (Figure 13). The raw air bladder was much thicker than raw mulloway, barramundi and jewfish air bladders. The catfish air bladders has 4 chambers, with two long chambers on the outer sides and two smaller chambers in the middle which are joined in the centre with a thick wall. It is quite thick in the centre and that part takes the longest to dry. The thickness was 5mm, which is thicker than the dried mulloway and barramundi air bladders from Section 3.

Figure 3 Thawed catfish air bladders.

Table 6 displays the results of the yields from the catfish bladders.

Table 6 Results for the wild catfish air bladders.

Sample	Treatment	Dimensions (mm)	Drying time (hr:min)	Wet weight (g)	Cleaned weight (g)	Dried weight (g)	% yield -wet weight	% yield-cleaned weight
1	Whole	55 x 55	27:30	34.73	33.22	13.42	38.6%	40.4%
2	Whole and clean	70 x 55	20:45	44.08	38.64	16.74	38.0%	43.3%
3	Clean and split	70 x 60	20:45	41.15	34.91	14.23	34.6%	40.8%
4	Clean and split	75 x 70	27:30	50.83	44.39	17.92	35.3%	40.4%
5	Whole and clean	70 x 65	27:30	46.46	41.17	17.71	38.1%	43.0%
6	Whole and clean	55 x 60	27:30	27.04	24.51	10.13	37.5%	41.3%
Average							37.0%	41.5%

Photos of the different treatments before drying are shown in Figures 14 and 15.

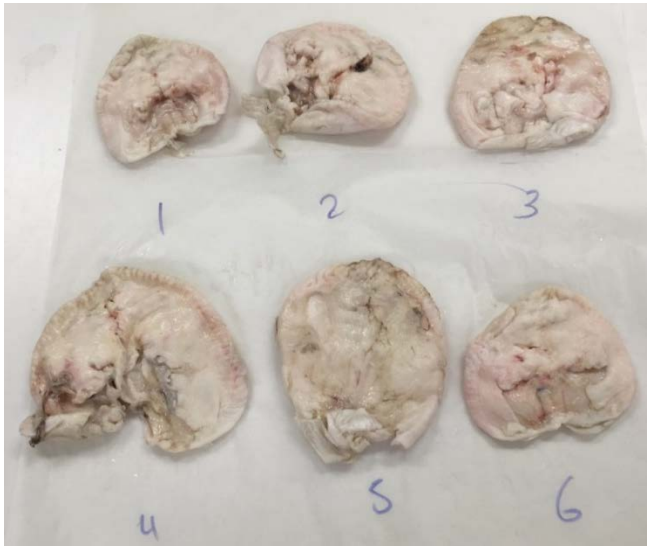

Figure 14 Wild catfish air bladders directly after sanitation

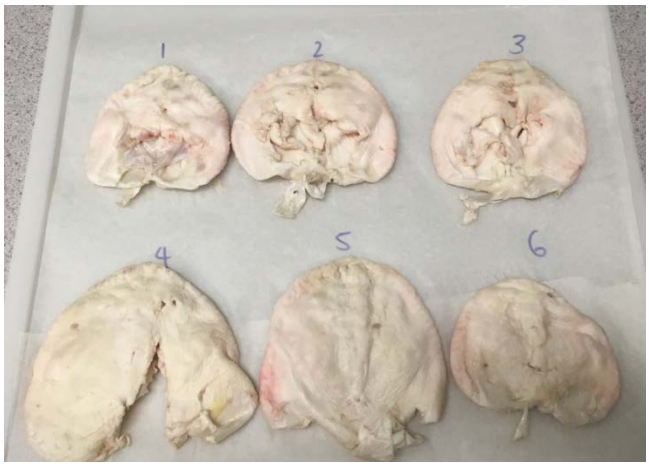

Figure 15 Wild catfish air bladders prior to drying

The dried product is not very oily and has a pleasant dried seafood smell (Figure 16 and 17).

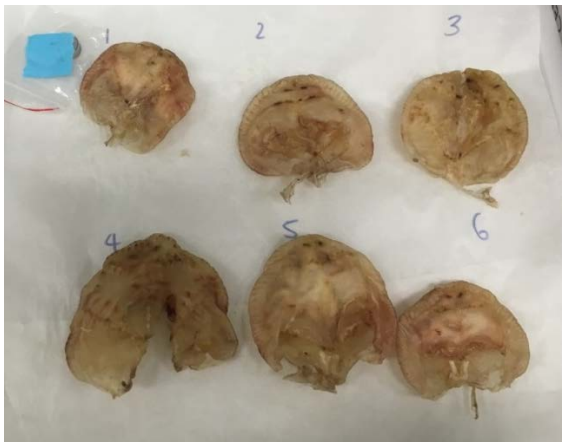

Figure 4 Wild catfish airbladder after 16 hours drying

Figure 5 Wild catfish air bladder after drying process had completed

After 2 months of ambient storage, the TPC was 1,800,000 cfu/g. The TPC was higher for the dried ocean cobbler than the other species and is unacceptable. The high TPC is likely due to the fact that the catfish air bladder was much thicker and after 27.5 hours there were still sections that were not completely dry. This moistness is likely to have encouraged bacterial growth. Due to the location of the four chambers, the best format to dry the air bladder would be to remove the internal membranes, open up the chambers slightly and dry whole.

4.4 Summary

The appearance of the dried ocean catfish airbladder is desirable, with a unique circular shape and thickness of 5mm. An issue with the trial was the even drying of the air bladder, with the central wall in the air bladder not dry after 27.5 hours, leading to unacceptable TPC. Further work to be conducted on a more effective process to evenly dry the air bladder in a suitable time frame.

5. Customer Feedback

5.1 Aim

To gather feedback from the target market on the quality of different species of dried air bladders.

5.2 Materials and Methodology

Samples of dried air bladders from the different trials which despatched to Dried Seafood Corporation to be observed by the target demographic and collate heir feedback on the quality including appearance, odour and thickness. A form for guiding responses is shown in Appendix 1.

The samples that were sent to the panellists are listed in Table 7.

Table 7 Samples of dried air bladders assessed by the target market

#	Species	Source	Age	Treatment
1	Barramundi	Dried Seafood Co.	1 month	Whole, Sanitised
2		Dried Seafood Co.	1 month	Whole, Sanitised and hand cleaned
3		Dried Seafood Co.	1 month	Whole, Sanitised, Hand cleaned and Puffed
4		Dried Seafood Co.		Split, sanitised
5		Sealanes	1 month	Whole, Sanitised
6		Sealanes	1 month	Whole, Sanitised and hand cleaned
7		Sealanes	1 month	Whole, Sanitised, hand cleaned and Puffed
8	Jewfish	Dried Seafood Co.	3 months	Split, sanitised
9	Mulloway	Fins	3 months	Split, sanitised
10	Cod	Overseas supplier	Unknown	Unknown
11	Ling	Overseas supplier	Unknown	Split
12	Wild Catfish	Westmores	2 months	Whole, sanitised

5.3 Results and Discussion

Chinese customers do not like the Icelandic Cod fish maw as they are appear ‘dirty’. The ‘dirty’ appearance is attributed to the black membrane that adheres to the fish maw after processing. The Chinese customers base the quality of fish maw on:

- Colour
- Thickness
- Cleanliness (for further detail on fish maw quality parameters see Section1).

Of the dried air bladders that had been assessed informally by the target market, the uncleaned whole barramundi fish maw was unacceptable as it looked ‘dirty’. The most acceptable barramundi samples had the membrane removed from the inside of the air bladder.

Other informal customer comments:

- Black membrane and grey colour of air bladder makes the air bladder look dirty, will not buy, even if it does taste good.
- The blood membrane in the middle may mean the fish is older and is better.
- Thicker Is better for the air bladder
- Does not think the gall stain is an issue. Airbladder will be soaked and cut into pieces and placed with flavourings

6. Conclusions and Next Steps

A process for cleaning, sanitising and drying air bladders has been optimised. Market feedback from drying of a variety air bladders for different species is being obtained. This work is on hold whilst awaiting market feedback.

Appendix 1

Product: Airbladders (Samples 1-4)

How would you describe this product/any comments:

Sample 1

Sample 2

Sample 3

Sample 4