Received: 2 February 2016 | Accepted: 18 September 2016

DOI: 10.1111/jai.13261

SHORT COMMUNICATION

WILEY Journal of Applied Ichthyology DWK

Does a diet including pellets from salmon cage farms affect the taste of wild saithe (*Pollachius virens* Linnaeus, 1758)?

I. Uglem[1] | E. M. Ulvan[1] | K. Toledo-Guedes[2] | E. Hegstad[3] | S. Blakstad[3] | B. Buserud[3] | B.-S. Sæther[4]

[1]Norwegian Institute of Nature Research, Trondheim, Norway

[2]Department of Marine Sciences and Applied Biology, University of Alicante, Alicante, Spain

[3]Hegstad & Blakstad Catering and Canteen, Trondheim, Norway

[4]NOFIMA, Tromsø, Norway

Correspondence
Ingebrigt Uglem, Norwegian Institute of Nature Research, Trondheim, Norway.
Email: ingebrigt.uglem@nina.no

Funding information
Norwegian Seafood Research Fund; Norwegian Research Council; Universidad Complutense de Madrid

1 | INTRODUCTION

The attraction of wild fish to net cage fish farms due to uneaten fish feed pellets that have fallen through the cages as waste feed, is a global phenomenon (Uglem, Karlsen, Sanchez-Jerez, & Sæther, 2014). The amount of feed not eaten by the farmed fish can reach up to 5% of the total amount in Norwegian salmon farming (Otterå, Karlsen, Slinde, & Olsen, 2009; Svåsand et al., 2015). This suggests that thousands of tonnes of waste feed are available to wild fish aggregating around these salmon farms. Farm-associated (FA) wild fish that have eaten a diet consisting partially of salmon feed are significantly fatter, with higher concentrations of terrestrial-derived fatty acids and lower concentrations of DHA in the muscle and liver than in unassociated (UA) fish (Dempster et al., 2011; Fernandez-Jover et al., 2011). Fish nutrition can influence the taste of the fish, either by variation in the biochemical composition of the tissues or by reducing the shelf life (Lie, 2001). Fishermen, fishmongers and consumers in Norway during the last couple of decades have reported that the taste of FA saithe (*Pollachius virens*) is inferior compared to UA fish (Uglem et al., 2014). The purpose of this study was to make taste comparisons of dishes made of either FA or UA saithe caught and processed using standardized means, by carrying out two simple consumer tests.

2 | MATERIALS AND METHODS

Saithe were collected near the island of Hitra (N63.62, E08.99) in mid-western Norway on two occasions (summer 2013 and spring 2015). On both occasions FA fish were captured less than 500 m from the same salmon farm containing farmed salmon above 1 kg. UA fish were sampled from locations 5–10 km distant from the nearest farm. In 2013, the fish were caught using commercial jigging machines (Belitronic BJ5000). In 2015, bottom gillnets were used (soaking time: 15–17 hrs). All fish were killed by a blow to the head, bled, gutted and cleaned within 1 hr after landing, then stored on ice (2–4°C) for 96 hrs in Styrofoam boxes (BEWI, Norway) before filleting. The fish were processed according to the statutory standard for fish treatment in Norwegian commercial fisheries.

Upon capture and before being bled, the total length (TL, nearest 1 cm) and the whole round body weight (W, nearest 10 g.) were measured. The amount of pellets in each stomach was weighed to the nearest 1 gram after gutting. Fulton's condition index was calculated with the formula: FCI = (Body mass/Total length^3) × 100). Hepatosomatic index (HSI) was calculated using the formula: HSI = (Liver mass/Body mass) × 100. The quality of the saithe was assessed using a modified quality index method (QIM) based on a method developed for quality assessment of Atlantic cod fillets (Akse, Tobiassen, Midling, & Aas, 2007). The quality index methodology is recognized as a reference method in sensory research (Bogdanović, Šimat, & Marković, 2012; Martinsdóttir, Luten, Schelvis-Smit, & Hylding, 2003; Ólafsdóttir et al., 1997). In the QIM test five fillet attributes (odor, gape, color, texture, surface) were scored by three trained evaluators. The maximum score was 12, with a decreasing quality in the fillet as the index value increased.

To determine if the FA saithe tasted differently from the UA saithe, two simple consumer tests were carried out at the canteen

 © 2017 Blackwell Verlag GmbH

TABLE 1 Morphometric parameters and frequency of fish with salmon food pellets in their stomachs, plus mean pellet mass and mean fillet quality assessment index

						Pellets in stomachs		
		N	Body mass (g)	*K*	HSI	Frequency (%)	Mass (g)	QIM index
2013	FA	25	3,183 (893)	0.98 (0.13)	9.9 (3.2)	92	77.2 (86.2)	2.4 (1.0)
	UA	20	2,090 (642)	0.86 (0.07)	6.0 (2.2)	0	0	1.9 (0.6)
2015	FA	30	3,193 (682)	1.04 (0.18)	9.9 (4.8)	50	88.4 (62.3)	2.6 (1.1)
	UA	30	2,470 (628)	0.84 (0.07)	6.2 (4.5)	0	0	1.7 (0.9)

In parentheses = standard deviations in fish when preparing fish burgers (2013) and oven-baked saithe fillets (2015). FA, UA, FCI, HSI and QIM = abbreviations for farm-associated, unassociated, Fulton's Condition Index, Hepatosomatic Index and Quality Index Method, respectively.

at the Norwegian Institute for Nature Research, Trondheim, Norway. In the first test in 2013, fish burgers were served to 105 persons. In the second test in 2015, oven-baked saithe fillets were served to 82 persons. The dishes were served with boiled potatoes, a simple salad and remoulade sauce. Each test person was served portions with two identically prepared burgers or pieces of fish, one each from a FA or an UA fish. The burgers or fish pieces were marked with differently colored plastic sticks. Test persons were not informed about the fish origins. In 2013, after the test each stick was deposited in one of three marked boxes: the stick from the preferred burger was put in a box marked "best" and the other stick in a box marked "not best". If the test person had no preference between the two burgers, both sticks were put in a box marked "no difference". In the second test in 2015, each test person was given a form and asked to write down the color of the stick of the preferred fish piece, or if there was no difference. In addition, they were asked simple questions regarding the appearance and taste of the fish (saltiness, bitterness, firmness and smell).

3 | RESULTS

In both tests, the FA fish had relatively larger livers and a higher condition index than the UA fish (Table 1, HSI—2013: $Z = -4.1$, $p < .001$, 2015: $Z = -2.7$, $p = .007$, FCI—2013: $Z = -3.9$, $p < .001$, 2015: $Z = -2.6$, $p = .01$). None of the UA fish had salmon feed pellets in their stomachs, but pellets were found in the stomachs of 92% and 33% of the FA fish in 2013 and 2015, respectively. The quality of the UA fish tended to be slightly better than for the FA fish (2013: $Z = -1.96$, $p = .05$, 2015: $Z = -1.8$, $p = .07$).

In 2013, 74% of the test persons noted a taste difference between the two fish burgers (Table 2). There were, however, no differences in the number of persons who has a preference (Binomial test, $p = .57$). In 2015, 9% of the test persons tasted no difference between the two pieces of oven-baked saithe, and with a higher number of test persons preferring the FA saithe (Binomial test, $p = .01$). Altogether 91% of the test persons claimed to see a difference in appearance between the fillet pieces, but had no difference in taste preference (51% vs 49%, Binomial test: $p = .91$). More than half of the test persons in 2015 (55%) reported that the saltier fish was better, and 78% of them preferred fish pieces from the FA saithe. There were no apparent trends with respect to bitterness, firmness or smell in the 2015 test.

TABLE 2 Number and percentages of test persons preferring a dish made of either farm-associated (FA) or unassociated (UA) saithe, plus numbers and percentages (in parentheses) of persons who tasted no difference

	Saithe burgers (*N* = 105)	Oven-baked fillet (*N* = 82)
FA preferred	36 (34.3%)	48 (58.5%)
UA preferred	42 (40.0%)	26 (31.7%)
No difference	27 (25.7%)	7 (8.5%)

4 | DISCUSSION

Our results show that there were no major differences in taste between fish burgers made from saithe that had a diet consisting partly of waste feed from salmon farms and saithe with a natural diet. However, there was a significant preference for oven-baked FA saithe. This difference may be related to a more pronounced saltiness, although both fish types were salted equally. As the FA saithe were fatter than the UA fish, the difference in perceived saltiness might be related to a difference in the absorption of salt between fat and less fatty fish. The taste analyses in the current study were designed as simple consumer tests and not intended to measure minor or detailed differences in taste and appearance; such tests would involve a panel of experts with trained evaluators and a more complex test design. However, our tests would most likely have revealed major differences in taste and appearance, and our results therefore do not support the viewpoint of FA saithe being inferior to UA fish (Uglem et al., 2014). To the contrary, our results indicate that oven-baked saithe fillets from FA fish were preferred over UA fish fillets. A lack of major differences is supported by QIM analyses that revealed minor variations only in flesh quality and the lack of major trends in a previous study, where saithe were fed salmon feed pellets under controlled conditions (Otterå et al., 2009). However, Skog, Hylland, Torstensen, and Berntssen (2003) found FA saithe to be rated slightly higher than UA saithe. Since the stomachs of FA saithe often contained large

quantities of partly-digested salmon feed pellets that would obviously give a negative visual and olfactory impression during gutting, we hypothesize that the general public skepticism to FA saithe is related to features other than taste.

ACKNOWLEDGEMENTS

We thank the fishermen Ole Jacob Øyen and Knut Magne Øyen, as well as Dr. Pablo Jerez-Sanchez, who assisted in the capture of saithe. We also thank the Marine Harvest for giving us access to their farm and we also thank the waiters at the Hegstad & Blakstad Catering and Canteen. This study was funded by the Norwegian Seafood Research Fund through the ProCoEx project (Project number: 900772) and the Norwegian Research Council through the project "ECOCOAST". Kilian Toledo-Guedes was supported by a grant from Iceland, Liechtenstein and Norway through the EEA Financial Mechanism, operated by Universidad Complutense de Madrid.

REFERENCES

Akse, L., Tobiassen, T., Midling, K. Ø., & Aas, K. (2007). Pre-rigor filetering av levendefanget torsk; Filetkvalitet – vill torsk restituert i merd etter fangst, uten fôring. NOFIMA Report 3/2007. ISBN: 978-82-7251-5, 16 pp.

Bogdanović, T., Šimat, V., & Marković, K. (2012). Development and application of quality index method scheme in a shelf-life study of wild and fish farm affected bogue (*Boops boops*, L.). *Journal of Food Science*, *77*, 99–106.

Dempster, T., Sanchez-Jerez, P., Fernandez-Jover, D., Bayle-Sempere, J., Nilsen, R., Bjørn, P. A., & Uglem, I. (2011). Proxy measures of fitness suggest coastal fish farms can act as population sources and not ecological traps for wild gadoid fish. *PLoS One*, *6*, 1–9.

Fernandez-Jover, D., Martinez-Rubio, L., Sanchez-Jerez, P., Bayle-Sempere, J. T., Lopez-Martinez, F. J., Bjørn, P. A., … Dempster, T. (2011). Waste feed from coastal fish farms: A trophic subsidy with compositional side effects for wild gadoids. *Estuarine, Coastal and Shelf Science*, *91*, 559–568.

Lie, Ø. (2001). Flesh quality – the role of nutrition. *Aquaculture Research*, *32*, 341–348.

Martinsdóttir, E., Luten, J. B., Schelvis-Smit, R., & Hylding, G. (2003). Developments of QIM—past and future. In J. B. Luten, J. Oehlenschlager & G. Olafsdottir (Eds.), *Quality of Fish from Catch to Consumer* (pp. 265–272). Wageningen: Academic Publishers.

Ólafsdóttir, G., Martinsdóttir, E., Oehlenschäger, J., Dalgaard, P., Jensen, B., Undeland, I., … Nielsen, H. (1997). Methods to evaluate fish freshness in research and industry. *Trends in Food Science & Technology*, *8*, 258–265.

Otterå, H., Karlsen, Ø., Slinde, E., & Olsen, R. E. (2009). Quality of wild-captured saithe (*Pollachius virens* L.) fed formulated diets for 8 months. *Aquaculture Research*, *40*, 1310–1319.

Skog, T. E., Hylland, K., Torstensen, B. E., & Berntssen, M. H. G. (2003). Salmon farming affects the fatty acid composition and taste of wild saithe *Pollachius virens* L. *Aquaculture Research*, *34*, 999–1006.

Svåsand, T., Kroon Boxaspen, K., Karlsen, Ø., Kvamme, B. O., Stien, L. H., & Taranger, G. L. (2015). Risikovurdering norsk fiskeoppdrett 2014. Fisken og havet, særnummer 2-2015, 172 pp.

Uglem, I., Karlsen, Ø., Sanchez-Jerez, P., & Sæther, B.-S. (2014). Impacts of wild fish attracted to open-cage salmonid farms in Norway. *Aquaculture Environment Interactions*, *6*, 91–103.

How to cite this article: Uglem I, Ulvan EM, Toledo-Guedes K, et al. Does a diet including pellets from salmon cage farms affect the taste of wild saithe (*Pollachius virens* Linnaeus, 1758)? *J Appl Ichthyol*. 2017;00:1–3. doi:10.1111/jai.13261.