

Adding value to under-utilised fish roe in Ireland: a comparison of physico-chemical and sensory characteristics of salted air-dried roe from Irish pollock (*Pollachius pollachius*) with commercial mullet and cod roe products (*Mugil cephalus* and *Gadus morhua*).

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Introduction

In Ireland, fish roe is generally either discarded at sea or processed as low-value fishmeal. The aim of this study was to establish the feasibility of developing a fish roe product to add value to this currently under-utilised nutritious seafood resource. Roe is the gastronomic term for the ovaries of a gravid female fish (OECD 1990). Roe includes products where individual eggs have been carefully detached from the gonads (e.g. caviar), as well as products made from the whole intact ovary. Fish ovaries are generally paired, and either fully or partially fused together (Bond 1996) as shown in Figure 1(i, ii, iv). Roes are high in marine oils and proteins (Slizyte *et al* 2014), have nutritionally beneficial long chain ω -3 PUFA and antioxidants (Kalogeropoulos *et al* 2008 and 2012) and therefore have the potential to be developed into value-added seafood products that are both nutritious and tasty, while contributing to the sustainability and profitability of the Irish fisheries industry. While not traditional in Ireland, many countries produce ready-to-eat food products using fish roe by salting and air drying. Salted air-dried mullet roe has been produced in the Mediterranean since the Phoenician era (Monfort 2002) and is known as 'Bottarga' in Italy and 'Avgotaracho' in Greece (OECD 1990). These high value products are sold either in whole or grated form: whole roe retailing up to approx. €250/kg (data not shown). Bledsoe, Bledsoe and Rasco (2003) described mullet bottarga as having a chewy mouthfeel with a rubbery texture and a yellow-ish red colour. Bottarga is generally consumed sliced or grated (Monfort 2002). According to Rosa *et al* (2016) mullet roe should be considered as a natural bioavailable source of omega-3, while Kalogeropoulos *et al* (2012) show how mullet roe also has antithrombotic potential. Given its geographical availability and suitability of roe size, pollock (a gadoid which spawns in the first half of the year and is commercially important in Irish fisheries) (Marine Institute 2017) was chosen to evaluate the feasibility of producing a salted air dried roe product.

Materials and Methods

Roe from Atlantic pollock, landed in Ireland, was salted and air-dried to manufacture a product similar to Mediterranean "bottarga". Processing methods were as described by Dimitriou *et al* (2016) though modified as follows: defrosted roes were salted (3% w/w) for 2h and dried on mesh trays using forced air flow for 4 to 7d drying time depending on initial roe weight. The final product was compared to commercially available dried roe products: 1) mullet roe produced in Sardinia and 2) cod roe produced in Norway, in terms of: dimensions; moisture content; pH; instrumental texture, colour (CIE L*, a*, b*). Sensory assessment was conducted with 38 consumers, using 9-point hedonic and 5-point Just About Right (JAR) scales to assess attributes and consumer acceptance of roe. The products were presented in both sliced and grated form.

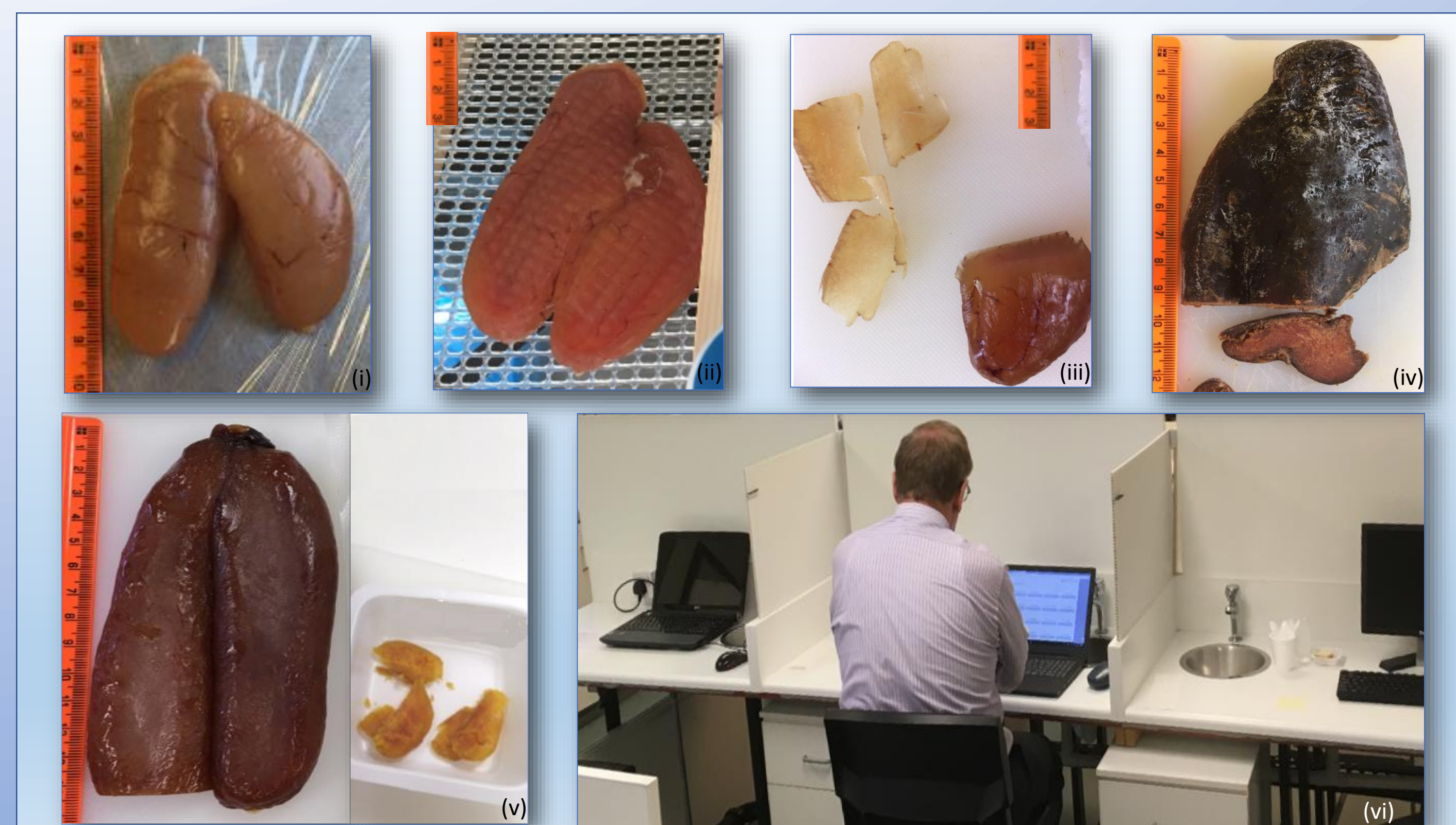


Figure 1: Top row: (i) raw pollock roe. (ii) salted air-dried whole roe on drying rack. (iii) sliced pollock roe. (iv) cod roe: whole and sliced. Bottom row: (v) salted dried mullet roe: whole and sliced; (vi) Sensory assessment using evaluation software (Compusense®).

Results

Pollock roe was smaller than both mullet and cod, with raw weights ranging from 31.1-308.8 g (mean of 105.0 g). Roes lost on average 3.1% moisture (w/w) after salting and mean 48.8% weight reduction was observed after 105 h average drying time. Moisture content of dried pollock roe was 34.2%; mullet was 28.2% and cod was 29.3% ($P < 0.05$). Raw pollock roe had a mean pH of 6.3, decreasing to 5.9 after drying, compared to 5.4 and 5.7 for mullet and cod products, respectively ($P < 0.05$). Instrumental hardness was similar in pollock and mullet, with cod being significantly harder ($P < 0.05$). The total colour difference (ΔE^*) between pollock and cod (outer surface and inner slice) was greater than that between pollock and mullet.

Table 1: Mean colour parameter values for whole roe products

External surface colour	L*	a*	b*	ΔE^*
Pollock (P)	42.95	5.10	7.20	-
Mullet (M)	41.05	4.13	5.06	$\Delta E^*_{pm} = 3.02$
Cod (C)	38.35	1.65	-0.16	$\Delta E^*_{pc} = 9.34$
Internal colour				
Pollock (P)	44.95	5.90	8.56	-
Mullet (M)	41.25	7.11	10.92	$\Delta E^*_{pm} = 4.55$
Cod (C)	48.77	10.26	12.67	$\Delta E^*_{pc} = 7.11$

Table 2: Mean pH of salted dried roe products and raw roe

Species	Salted dried roe		Raw roe	
	Mean pH (SD)	Range	Mean pH (SD)	Range
Pollock	5.91 (0.12) ^a	5.74 - 6.16	6.29 (0.04)	6.22 - 6.33
Mullet	5.41 (0.02) ^b	5.38 - 5.44	n/a	n/a
Cod	5.74 (0) ^a	5.74 - 5.74	6.62 (0.14)	6.42 - 6.76

Table 3: Mean texture for salted dried roe products

Species	Penetrometry Hardness (N)	TPA Hardness (N)	Cohesiveness
Pollock	14.49 ^a	116.04 ^a	0.47 ^a
Mullet	14.62 ^a	126.36 ^a	0.43 ^a
Cod	58.52 ^b	N/A	N/A

TPA for cod is not representative as most samples overloaded the cell

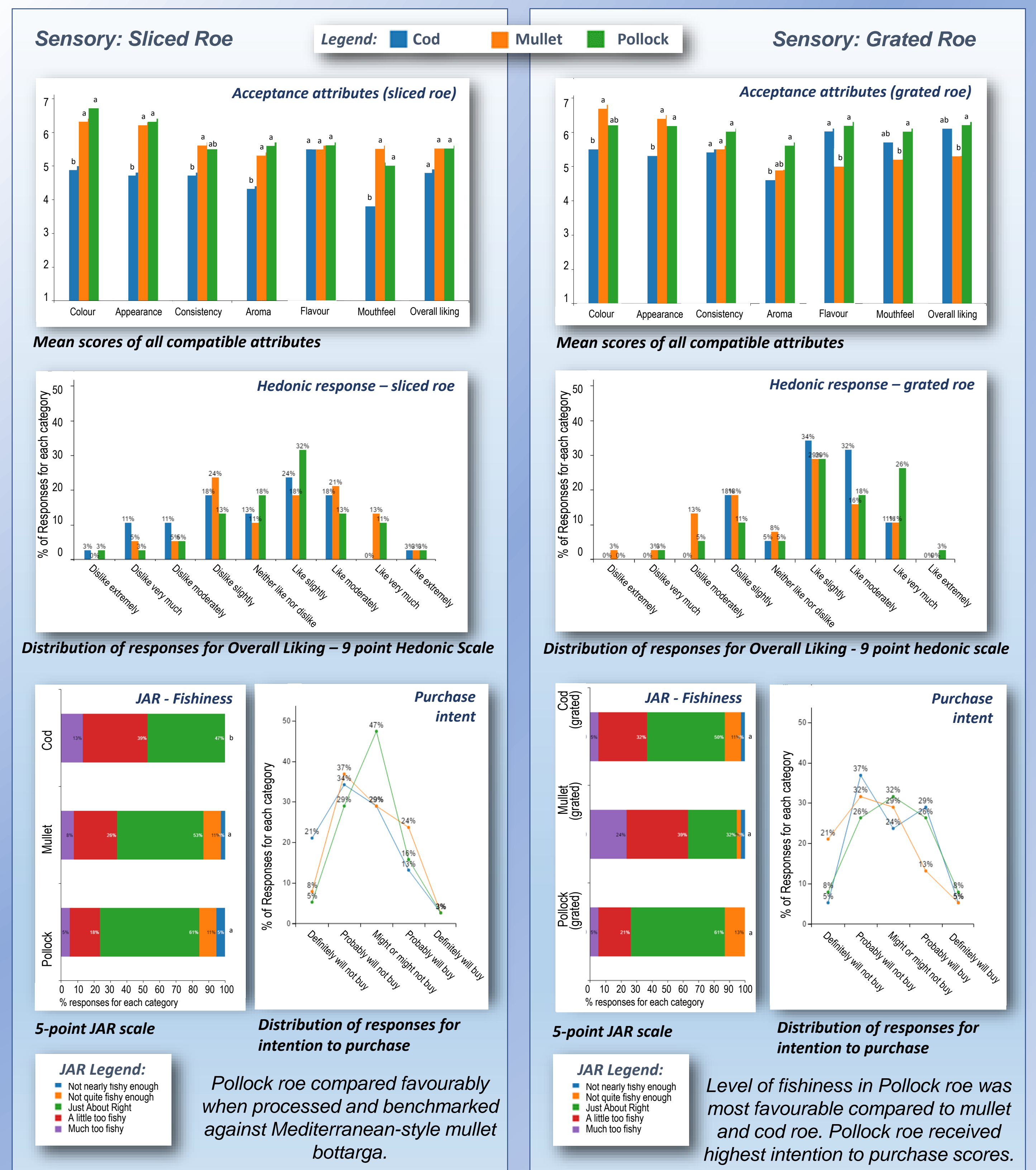
Table 4: Mean moisture content of salted dried roe products

Species	Mean Moisture Content % (SD)	Range (%)
Pollock	34.16 (3.75)	29.00 - 40.33
Mullet	28.17 (2.13)	24.88 - 30.11
Cod	29.33 (0.83)	28.50 - 30.17

Different superscript letters represent significant mean differences ($P < 0.05$) between groups.

Results

Overall, pollock and mullet scored similarly on many sensory attributes. When assessing sliced samples, all species scored similarly for flavor, while mullet scored lowest ($P < 0.05$) when grated samples were assessed. Overall liking of sliced air-dried pollock was similar to commercial mullet and cod, averaging 5.6, 5.6 and 4.9, respectively ($P > 0.05$). However, the overall liking of grated pollock and cod increased to 6.3 and 6.1 respectively while grated mullet decreased to 5.3 ($P < 0.05$). This was possibly due to greater acceptance of powdered texture compared to sticky mouthfeel of sliced products. Analysis of the top four Overall Liking hedonic responses for pollock, mullet and cod was: 57.9% 55.3% 44.7% for sliced samples compared to 76.3%, 55.3% and 76.3% for grated samples. Pollock received the highest Intention to Purchase response as the top three analysis for sliced pollock, mullet and cod was 65.8%, 55.3% and 44.7% respectively, and for grated products was 65.8%, 47.4% and 57.9% respectively. JAR scales were used to determine perception of fishiness, savouriness, saltiness, bitterness and acidity. Penalty analysis of JAR responses showed the overall liking of all products was impacted by perception of fishiness, with consumers penalising the products if they were either "too fishy" or "not fishy enough".



Conclusions

Comparisons of salted dried pollock roe with similar commercially available mullet and cod products indicated a range of similar sensory and physico-chemical characteristics. Sensory analysis showed favourable consumer acceptability of the pollock products, with the right level of fishiness, very acceptable appearance for the sliced products and comparable mouthfeel, flavour and acceptability to the highly valued mullet bottarga for grated products. The use of this nutritious yet undervalued fish ingredient for the development of food products could offer an opportunity to add value to fish landed in Ireland while contributing to waste reduction in the fishing industry.

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