Aquaculture production and use of insects for feed: a consumer perspective

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Abstract

Worldwide, aquaculture is assuming ever more importance in diminishing the pressure on wild stocks in the seas. Prices of feed used in farming fish are increasing, due the rise in demand. Research on sustainable sources of feed was recently intensified and insects as meal to substitute soybean and fish meals and oils seems a promising field. Consequently we explored future consumer attitude toward the consumption of fish farmed on insect meals, as a mean of enhancing the sustainability of the farming system in aquaculture. We focused our attention on Italian consumers of fish and the results show a sensitive consumer, willing to try an innovative product, interested in research to improve the safe-guarding of marine resources.

Keywords: aquaculture; fish farming; sustainability; insects.

1. Introduction

In recent years finfish production in Europe has increasingly become the subject of attention from an environmental and economic sustainability perspective. Intensive current finfish farming practices and consumption patterns in high-income countries are associated with ecological pressure and marine over-exploitation. Aquaculture has achieved 42% of global fish supplies by weight (FAO, 2014) and the continued increase in the demand for fish products has caused a rise in feed prices, such as fish meals, fish oil, soybean meals. The EU has proven to be the major consumer market of seafood products in the world, with 12.3 million tons, equal to € 52.2 billion in 2011. It is the primary importer of seafood products, purchasing 24% of total world exchanges in value (EUMOFA-EU Commission, 2014). At the same time the demand for fish products in Europe is increasing due to the interest of consumers towards healthy and affordable products (Menrad, 2003; Frewer et al. 2007; Niva and Makela, 2007; Verbeke, 2011). Moreover, in the European Union the dependence on the importation of fish products is growing, so it is urgent to verify both the cost and the economic advantage for aquatic producers to introduce innovations in feeding practices. For example, one of the more interesting solutions to feeding fish is the use of insect meal to substitute fish and soybean meal (van Huis, 2013).

The objective of this study is to investigate the attitude of Northern-Italian consumers of farmed fish on two aspects: interest in marine ecology and awareness of limited resources for fish farming and level of trust in eating finfish products if fed on insect meals.

The paper is organized as follows: Section 2 focuses on the literature that deals with these issues. Section 3 focuses on the finfish sector, Section 4 presents the materials and methods utilised, Section 5 reports the results and Section 6 discusses main conclusions.

2. The literature review

In the literature, sustainable food consumption has been extensively studied (Verein et al., 2012) but it is no easy matter to obtain reliable information on consumer preferences for new environmental/ethical products introduced in the market. Consumer interest in sustainability related to fish was investigated recently by Verbeke (2007a, 2007b) and Vanhonacker et al. (2011), whereas Stefani et al. (2012) analyzed Italian consumer preferences for farmed sea bream, as well as paying attention to the type of feed (fish and vegetables or only fish) used in farming. However, there do not seem to be studies focused on the type of feed used for farmed fish linked to sustainability issues. Instead in recent times, several studies have been conducted from a nutritional point of view in order to verify the use of insect meal to substitute fish and soybean meal (van Huis, 2013). Scientists consider the insect meals a valid alternative source of animal protein and have studied the nutritional features, in terms of amino acid profile and composition of fatty acid (Barroso et al., 2014, Gasco et al. 2014a, Gasco et al. 2014b, Sánchez-Muros et al. 2014a, Schiavone A. 2014).

In this perspective it is essential to know the opinion of consumers in order to provide support to producers in deciding whether to adopt insect meals as feed for fish. European Union policy supports these issues by financing dedicated projects, but the opinion of consumers of farmed fish regarding the introduction of insects as feed is at the moment unknown (Smith and Pryor, 2014). There is little knowledge about consumer preferences and obstacles to using insects as animal feed; consequently it is necessary to obtain more information in order to set up commercialization strategies (van Huis, 2013).

3. Exploring the finfish sector

The Italian fisheries sector has a different trend compared to the European Union. From the analysis of the dynamics of the main economic variables, the situation is not positive (ISMEA, 2009, 2013). In fact, the fisheries sector in Italy has been having difficulties since the year 2000, as also shown by all indicators for 2012 compared with 2007 (table 1). Aquaculture production and marine catches, employment, value of the product and consumption have decreased. Currently the value of production amounts to 936 million euro for marine capture and 524 million euro for aquaculture, for a total amount of 1,460 million euro (it was more than 2 billion euro in 2007). Consumption amounted to 19.8 kg in the year 2012, above the world average (19.2 kg, FAO 2014) but down compared to the past (22.1 kg in 2006, 21.9 kg in 2007). Since the marine life caught in the Mediterranean cannot increase, aquaculture is identified as a means to tackling these difficulties and interrupting the decline of the sector. New species of fish will be introduced in farming, to improve the competitiveness of aquaculture and sustainability of the sector.

Tab. 1 - Italian indicators of marine fish and aquaculture

Indicators:	2007	2012
Total production (t):	524.000	392.639
Marine capture (t):	277.000	197.839

Aquaculture (t):	247.000	194.800
Imports (t):	915.000	903.038
Exports (t):	141.000	117.232
Per capita consumption (kg):	21,9	19,8
Self-sufficiency rate (%):	40,4	33,3

Source: ISMEA (2009, 2013)

4. Materials and methods

We carried out a survey of Northern Italian consumers of fish during summer-autumn 2014. A sample of 277 respondents was stratified by age and gender on the basis of the composition of the Italian population. The study is based on face-to-face interviews. We conducted the survey in three districts of the Piedmont region, in two different types of venue: 127 respondents were interviewed in local outdoor markets and 150 in supermarkets.

Following Verbeke et al. (2007c) to reveal the interest that the consumer places on sustainability issue*s* linked to marine ecology and the attitude toward finfish produced with insect meals, we included six components relevant to food consumer science (Table 2). The first component corresponds to consumers' fish-purchasing habits; the second corresponds to drivers of fish consumption; the third to consumer knowledge of marine over-exploitation and raw materials used for feeding farmed fish; the fourth to consumer interest in the sustainability of fish farming and the fifth to consumer attitude toward insect meal as a feed substitute for fish and soybean meals. Finally, socio-demographic and economic characteristics were collected. A questionnaire was developed with these components using a multiple-choice format with rating or dichotomous scales. Firstly we carried out a descriptive analysis to study the characteristics of the sample and the frequencies of the answers. Subsequently we use*d* the ordinal logistic regression (McCullagh, 1980 and 1998) to predict three different ordinal dependent variables given 24 independent variables. Between these we utilize*d* 20 ordinal variables and 4 categorical variables[1]. The dependent variables with rating scale are listed below:

IS= interest in research in sustainable feed for fish farming (score 1-4)

CA= consumer attitude toward use of insect meal (score 1-3)

WB= Willingness to buy fish farmed on insect meal (score 1-3)

For the aim of our work we considered the following functional relations:

$I=f(FP,DC, K, I, AT, SE)$ [1]

$CA=f(FP, DC, K, I, AT, SE)$ [2]

$WB=f(FP, DC, K, I, AT, SE)$ [3]

[1] At first we considered all the possible independent variables but later removed some variables to solve problems of multi-collinearity.

Tab. 2 - Components used for questionnaire

Components	Demands	Scale/Categories	N	Mean	SD
FP	Interview site (category)	0-1	277	-	-
(fish-purchasing habit)	Fish purchasing frequency	1-5	277	3,97	1,08
	Type of fish purchased (categorical)	1-3	277	-	-
DC	Reasons for purchasing fish (categorical)	1-3	277	-	-
(drivers of fish consumption)	Importance of price	1-4	277	3,10	0,72
	Importance of origin	1-4	277	3,37	0,80
	Important if italian or foreign origin	1-4	277	3,26	0,85
	Important if farmed or wild caught	1-4	277	2,88	0,88
	Importance of appearance	1-4	277	3,72	0,58
	Importance of nutritional aspects	1-4	277	2,86	0,97
	Importance of certification	1-4	277	2,94	1,03
	Importance of other factors	1-4	277	2,11	1,31
K	Knowledge of over-fishing	1-2	277	1,07	0,25
(consumer knowledge)	knowledge of feed provided (categorical)	1-5	277	-	-
I	Interest in research in sustainable feed	1-4	277	3,32	0,74
(interest in sustainability of fish farming)	Interest in type of fish feed	1-4	277	3,05	0,78
AT	Attitude toward use of insect meal	1-3	277	2,40	0,67
(consumer attitude toward finfish produced with insect meals)	Willingness to buy fish farmed on insect meal	1-3	277	2,69	0,61
	Negative factors: distaste	1-4	277	3,68	0,57
	Negative factors: quality	1-5	277	3,05	1,00
	Negative factors: trust	1-6	277	3,21	1,15
	Expected price for fish farmed on insect meals	1-3	277	1,93	0,75
	Willingness to pay more for fish farmed on insect meal	1-2	277	0,13	0,42
SE	income	1-4	277	1,07	1,31
(socio-economic-demographic factors)	gender (categorical)	1-2	277	-	-
	age	1-7	277	4,11	1,25
	education	1-4	277	2,98	0,80
	employment (categorical)	1-12	277	-	-
	family size	1-4	277	2,43	0,70
	BMI	continuos	277	23,28	3,36

We chose these different variables based on our interest in distinguishing general interest in this topic compared to the effective decision to purchase.

Ordinal regression provides a useful extension of the binary logistic model in those situations where, precisely, a dependent variable is ordered. An ordinal logistic model takes the following form:

$$c_j(X_i) = \ln\left\{\frac{P(Y > j|X_i)}{P(Y \le j|X_i)}\right\} = \beta_1 X_{i1} + ... + \beta_k X_{ik} - \alpha_{j+1}$$

In our empirical model:

i=1,....277; corresponds to number of consumers interviewed

j=score from 1 to 3 (or j=1,…4 for “IS” dependent variable)

k=1,...24; corresponds to number of independent variables

Y= response variable

Xi=independent variables (answers for each consumer)

β= regression coefficients

α = parameter referred to as “cutpoints” between intervals of values of response variable.

β coefficients represent the log odds ratio of scoring > j versus ≤ j for a one unit change in X.

Provided that we use several independent variables that should be highly correlated with each other, multicollinearity problems may occur. This leads to difficulties with understanding which independent variable contributes to the explanation of the dependent variable and technical issues in calculating an ordinal regression. Therefore we quantify the severity of multicollinearity by variance inflation factor (VIF). It provides an index that measures how much the variance (the square of the estimate's standard deviation) of an estimated regression coefficient is increased because of collinearity.

5. Results

An overview of the six groups of questions with means and standard deviations is presented in table 2.
The sample analyzed includes 62.5% of women and 32.5% of men. Sixty one point four percent were equally distributed between the ages of 45-54 and 55-64 years old, 15% were in the 35-44 year-old range. The level of education is medium-high: 47.3% of respondents have a high school diploma and 27.1% hold a university degree. For 39% of the sample, monthly income amply covers expenses whereas 45% have to keep a close eye on spending. Sixteen percent have highly limited purchasing power and as a result, this group is often forced to do without . The employment of respondents was varied: 28.2% were office workers, 20.9% retired, 12.3% housewives, 8.3% factory workers, 4.7% teachers, 4.3% self-employed, 3.6% students, 1.1% unemployed, 0.7% executives 12.6% other. Fifty four point five percent of respondents come from families with 3-5 members, 33.2% come from 2-person families and 11.9% live alone. The BMI (biomass index, height x weight) shows that most respondents had a normal body weight (66.8%), 28.2% were overweight (of whom 4% were obese) and 5.1% were underweight.
Descriptive results show that almost 90% of consumers have a positive attitude toward insect meal and most of the respondents (76%) intend to purchase and eat farmed fish even though fed with insect meals, so long as the hygiene requirements are met. A small group (7,6%) stated it would not buy this type of fish product, 95% saying it was because they feel uncomfortable with the use of this new feed; 74% do not trust the production process; 42% think that the quality (taste and other parameters) of the product could be highly compromised while 32% felt it could be somewhat damaged. Generally the majority of consumers (93,1%) are aware of the problem of limited resources for fish farming.
We then analyzed consumer opinion against the market price that a new product such as fish fed with insect meal could have. About half of the sample (46.2%) believe that the price will be the same as traditional fish products; 29.2% think that the product will have a lower price either because insect meal costs less than traditional feed or in order to promote it on the market. On the other hand, 23.8% of people expect a higher price for three reasons: 1) because they do not think that works that produce insect meals currently exist in the European Union and therefore they would have to be built. The respondents think they have to be built in the EU zone because they believe that hygiene is more regulated compared to non-EU countries. 2) because sustainable products have a higher price due to the intrinsic added value, 3) because it is an innovative food that incorporates the cost of research. From a group of respondents we investigated the willingness to pay a higher price for the more sustainable fish: demographics and social variables seem to be relevant factors in determining this positive attitude.
Ordinal regression results for the three models are reported in table 3. To solve multicollinearity problems in the last version presented we have removed some variables after checking "tolerance" and "VIF -variance inflation factor-" values for each predictor.
The overall fit of the model is reasonably good with Pseudo R^2 measures ranging between 0.137 and 0.537. For equation [1] all six components are significant for at least one variable. Where consumers are interviewed appears significant and with high value so we can conclude it is an important predictor. The positive sign indicates that consumers who utilize outdoor markets are those more interested in research in marine ecology and awareness of limited resources for fish farming. This interest is also affected by

the frequency of fish purchase, origin, national/foreign provenance of the fish and the presence of certification. Nonetheless, those who have a greater knowledge of over-fishing issues are less interested in these topics. Moreover all the socio-economic variables show significant βs estimates. In particular education, age, BMI and gender result in predictors positively affecting consumer interest whereas income and family size have a negative effect.

Table 3 – βs estimates of ordinal regression

		IS		CA		WB	
	α_1	3,162		5,992	***	-1,452	
	α_2	4,989	**	9,555	***	0,908	
	α_3	7,727	***				
FP	Interview site (category=local market)	1,27	**	-1,122	*	-1,493	*
	Interview site (category=supermarket)	0[a]		0[a]		0[a]	
	Fish purchasing frequency	0,245	*	-0,02		-0,208	
	Type of fish purchased (category=farmed fish)	0,168		0,124		-0,62	
	Type of fish purchased (category=caught fish)	0,238		-0,513		0,056	
	Type of fish purchased (category=both)	0[a]		0[a]		0[a]	
DC	Reasons for purchasing fish (category=I like)	0,163		-0,408		0,571	
	Reasons for purchasing fish (category=healthy)	-0,45		-0,088		0,028	
	Reasons for purchasing fish (category=both)	0[a]		0[a]		0[a]	
	Importance of price	-0,101		-0,43	**	0,571	**
	Importance of origin	0,415	*	-0,232		0,13	
	Important if italian or foreign origin	-0,359	*	0,128		-0,177	
	Important if farmed or wild caught	0,101		-0,12		-0,52	*
	Importance of appearance	-0,114		0,586	**	0,042	
	Importance of nutritional aspects	-0,009		0,043		-0,166	
	Importance of certification	0,241	*	0,014		0,121	
	Importance of other factors	-0,077		0,137		-0,116	
K	Knowledge of over-fishing	-1,3	**	-0,543		0,797	
I	Interest in research in sustainable feed			0,526	***	0,276	
	Interest in type of fish feed	0,4	**	0,335	*	-0,299	
AT	Attitude toward use of insect meal	0,596	**			2,656	***
	Willingness to buy fish farmed on insect meal	0,315		2,43	***		
	Expected price for fish farmed on insect meals	0,14		-0,02		0,592	**
	Willingness to pay more for fish farmed on insect meal	0,313		0,2		-0,284	
SE	income	-0,441	**	0,34		0,439	
	gender (category=F)	-0,852	***	-0,157		0,005	
	gender (category=M)	0[a]		0[a]		0[a]	
	age	0,301	**	-0,266	**	0,143	
	education	0,33	*	-0,272		0,097	
	family size	-0,345	*	0,237		0,027	
	BMI	0,107	**	0,025		-0,154	***
	Pseudo R^2:						
	Cox e Snell	0,246		0,409		0,404	
	Nagelkerke	0,282		0,482		0,537	
	McFadden	0,137		0,277		0,371	

*Note: ***, **, * denote 1%, 5% and 10% level of significance respectively.*

Considering equation [2] we first note that between factors relating to fish purchasing habits only the place where the interview was conducted affects consumer attitude in eating finfish products if fed with insect meals. Interestingly, price is both a significant and negative factor; this means that those who

consider price an important driver for fish purchase are less likely to agree to the use of insect meals. Fish appearance is a positive predictor of this attitude and also highly significant is the willingness to purchase fish fed with insects and an interest in marine ecology. Finally, age is significant and negative, that is the younger the consumer, the higher the probability they agree with innovation.
The predictors affecting the willingness to purchase this kind of farmed fish are analyzed in equation [3]. The first interesting result is still the place where the interviews are conducted, that is, if consumers are at outdoor markets, they are less willing to buy this kind of fish. Price appears as a significant factor affecting the dependent variable in a positive manner as well as expected price for fish farmed on insect meals. This result tells us that the consumer that considers price an important aspect in the purchase of fish tends to be more willing to buy fish farmed on insect meals. Moreover those who expect that this particular type of fish will be more expensive are the same ones who are more likely to buy it. We could justify this result assuming that consumers more favorable to fish fed with insects consider it as a sustainable product with a higher price due to the intrinsic added value and as an innovative food incorporating the cost of research.
Contrary to findings of some works in the literature (Claret et al. 2012, Agrawal and Kamakura, 1999) the origin is not a significant factor for the purchase but this may be justified by the fact that the focus is not placed on the fish in general but on a specific product farmed with particular characteristics.

6. Main conclusions

In this work we analyzed interest, attitude and willingness of consumers regarding finfish products fed with insect meals. We carried out a survey utilising a questionnaire on a sample of Northern-Italian consumers.
This is one of the first exercises trying to empirically analyze both consumer attitude to sustainable fish products fed with insects and consumer interest in sustainability issues.
Descriptive results show that the majority of consumers (93.1%) are aware of the problem of limited resources for farming fish. Almost 90% of consumers have a positive attitude toward insect meal and most of the respondents intend to purchase and eat farmed fish even though fed with insect meals, so long as the hygiene requirements are met.
Ordinal regressions were used to determine which factors are significant in affecting interest in research in sustainable feed for fish farming, consumer attitude toward use of insect meal and willingness to buy fish farmed on insect meal.
In particular, interest is mainly affected by socio-economic variables, knowledge of the issue and the interest attributed to origin and certification. Positive attitude is mainly influenced by interest in this issue and variables linked to appearance and price, whereas the willingness to buy fish fed on insect meals is closely linked to the importance of price and expected price for this kind of fish.
One of the most important aspects that emerges is that there is a marked difference in the results of the three equations: the predictors that influence the three dependent variables are often different or of a different sign. This leads us to conclude that there is a real difference between interest and actual willingness to buy. Overall what emerges is that interest in sustainability is more affected by socio-demographic characteristics whereas the decision to really purchase this kind of product depends on the importance that consumers place on price. Interest in sustainability issues seems to be less significant in affecting the decision to purchase.

Our paper offers two main contributions. Firstly, from a consumer perspective it provides an analysis of an issue that has not been empirically investigated in literature, increasing the knowledge of consumer attitudes towards sustainable food products. Secondly, our findings could be useful to support decisions of European Union policy in financing dedicated projects and to producers in developing appropriate input purchase strategies.

As the European Union is the largest consumer of fish in the world and the largest importer, it is essential to increase internal production. Moreover, the health of consumers benefits from a daily-weekly presence of fish products in the diet. In order to reduce the pressure on the seas, we have to encourage aquaculture. To this aim the use of insect meal to substitute fish and soybean meal should be a suitable solution in terms of sustainability. Future research should check whether the use of insect meal feed is more expensive than the conventional one. In this case European Union policymakers for fisheries may decide to support aquaculture producers.

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