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# The attitudes of Italian consumers towards jellyfish as novel food

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ABSTRACT

The globalization of food markets and the recent upgrade of the European regulation on novel foods open up new possibilities for the introduction of edible jellyfish in the diet of Europeans. In spite of no tradition of eating jellyfish in Italy and, more generally, in Western countries, several Mediterranean jellyfish species have biological and nutritional features with a large potential as innovative, sustainable novel food and source of bioactive compounds. To evaluate the Italians' attitude of considering jellyfish as food source, a survey has been carried out on a group of 1445 individuals. A questionnaire was designed to assess the jellyfish consumption attitude (JCA) of respondents and explore the effect of their individual traits (socio-demography, personality, behavior habits, neophobia, disgust sensitivity) on JCA. Gender, age, and travelling habits differently affected JCA. Possible culinary uses and food pairing of jellyfish were also significantly influenced by JCA. Individuals with the highest propensity to accept jellyfish as food are young people, familiar with the sea environment, with high education level or students, and frequent travelers. Food neophobia and sensitivity to disgust are confirmed as personality traits able to strongly impair the acceptability of a novel food. Finally, this work provides insights into the acceptance and rejection variables that should be taken into account when an unfamiliar new food product, such as jellyfish, is planned to be introduced in a new dietary culture and new markets.

## 1. Introduction

Scientific research and reports of inter-governmental organizations jointly point out the need of changing global food consumption patterns to foster sustainable consumer behavior and achievement of biodiversity conservation goals (Robins, 1999; European Commission & Consumption, 2008; FAO, 2008; UNESCO, 2010; FAO, 2017). Shared recommendations advocate consumption of local, low-industrialized and renewable food products (FAO, 2011) increasing the awareness that consumers' food choices represent significant environmental decisions. Recently, regarding seafood products the FAO fishery guidelines focused on "eco-labelled fish products" (FAO, 2018) to enhance sustainable seafood production and environmental protection to mitigate impacts of sudden climatic change and biotic modifications. Indeed, climate change threatens the performances of food systems to provide adequate nutrition to a fast-growing human population (Campbell et al., 2016). Fishery- and aquaculture-based coastal economies deserve special attention as they suffer diminishing catches and seafood harvest due to shifts in fish distribution and reduction of biodiversity and productivity of aquatic ecosystems, directly or indirectly linked to climate change (FAO, 2008; Allison et al., 2009; Barange, Bahri, Beveridge, Cochrane, Funge-Smith, & Poulain, 2018). In response to these challenges, concerted efforts must be undertaken to implement climate resilient food systems able to cope with or adapt to the disturbed state, such as the overfishing control and increase of fishery diversification (Cline, Schindler, & Hilborn, 2017).

Multiple human-driven impacts, such as ocean warming, overfishing and eutrophication are regarded as interacting causal agents linked to recurring proliferations (*outbreaks* or *blooms*) of gelatinous zooplankton, i.e. jellyfish (Purcell, 2005; Purcell, Uye, & Lo, 2007; Richardson, Bakun, Hays, & Gibbons, 2009; Boero, Brotz, Gibbons, Piraino, & Zampardi, 2016). Seemingly, the frequency and abundance of jellyfish outbreaks are reported on the rise in many world coastal waters, affecting the structure and organization of marine biological

*Abbreviations:* DS, Disgust sensitivity; EFA, Exploratory Factor Analysis; FN, Food neophobia; HMLR, Hierarchical multiple linear regression; JCA, Jellyfish Consumption Attitude; PCA, Principal Component Analysis

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communities (Arai, 1997; Graham & Bayha, 2008; Boero, 2013; Dong, Liu, & Keesing, 2010) with a direct impact on sea-based human activities, including fishery, aquaculture, coastal industries and tourism (Dong et al., 2010; De Donno et al., 2014; Bosch-Belmar et al., 2016; Bosch-Belmar et al., 2017). Long-term studies on the gelatinous component of the Italian marine fauna (Boero et al., 2016) unraveled the occurrence of conspicuous jellyfish blooms in the Mediterranean since (at least) 2009. Based on available scientific evidence or on "Occhio alla Medusa", a basin-wide Mediterranean citizen science initiative, increased abundance of both native and non-indigenous jellyfish species have been reported in the Mediterranean over the last 20 years (Brotz & Pauly, 2012; Boero, 2013; Boero et al., 2016). As an example, the density of a single population of *Rhizostoma pulmo* in the gulf of Taranto (Ionian Sea), yearly recorded since 2011, reached around 300 tons /km$^2$ in 2014 (A. Leone, personal observation).

In this scenario, jellyfish could be alternatively considered a nuisance or a novel food/feed resource. In Europe, the lack of tradition for edible jellyfish and the presence of strict food safety rules, made the edible jellyfish market still virtually absent or possibly restricted to the Asiatic immigrant community only. In the absence of significant consumption, jellyfish are labeled as "novel food" under the current European Regulation (EU Regulation 2015/2283 of 25/11/2015 http://eur-lex.europa.eu/eli/reg/2015/2283/oj), while recent research has suggested jellyfish as raw material for novel foods in European Countries, too (Bleve, Ramires, Gallo, & Leone, 2019).

The main factors controlling acceptance and consumption of foods are availability, cost, hedonic preference, and nutritional value. Anyway, additional factors play an important role in the selection or non-selection of still untried foods, namely novel foods, such as the local non-availability, idiosyncrasies in food practices, health concerns or religious and/or cultural taboos, risk perception, available information, consumer knowledge, as well as personality traits (de Boer & Bast, 2018; Menozzi, Sogari, Veneziani, Simoni, & Mora, 2017;; Piha, Pohjanheimo, Lähteenmäki-Uutela, Křečková, & Otterbring, 2016). For instance, the food neophobia (Pliner & Hobden, 1992) namely the unwillingness to try unfamiliar foods and the picky eating seem related to high body mass index (BMI) in gender-independent way (Knaapila et al., 2015) and, supposedly, to a reduced adaptation to diet changes.

The survey on the acceptance of edible jellyfish by Italian consumers represents an interesting case-study due to many events such as common unfamiliarity of the item, the deep-rooted food traditions and the recent exposition to the presence of jellyfish as raw material at local level. In addition, although many studies have already conducted on insects as novel food in the population of Western countries, including Italy (Menozzi et al., 2017 and literature therein), at our best knowledge no specific survey was carried on jellyfish as novel food.

In Eastern food systems, edible jellyfish are considered as a resource, following a millenary tradition as healthy food, with an increasing market demand. The high appreciation for jellyfish-based food in Eastern Countries is proved by the presence of "artificial jellyfish" in Chinese cuisine, and later carried on in the Chinese food industry (also testified by a related patent). This "artificial jellyfish" is a novel food in China, made with processed seaweed and gelatin, comparable in look and quality with natural jellyfish. In Chinese culture, "artificial" has a more positive connotation than in Western culture, thus jellyfish is considered a valuable and hedonic food product worth to be copied. Conversely, in Western Countries, the complete lack of gastronomic tradition make jellyfish an entirely new item, free from previous cultural connotations and associations. Therefore, the perception of edible jellyfish in Eastern and Western Countries cannot be compared since preexisting experience, tradition and information may modify the explicit attitude towards the same unfamiliar food item in the direction of the valence of the information.

In Asiatic Countries, jellyfish commercially exploited for food production are uniquely represented by scyphozoan cnidarians, namely about twenty species belonging to the rhizostomean genera *Rhopilema*, *Nemopilema*, and *Stomolopus*, whose large size and body texture foster their exploitation as food (Hsieh, Leong, & Rudloe, 2001; Omori & Nakano, 2001; Dong et al., 2010; Kitamura & Omori, 2010). Recent analyses showed a global increase of jellyfish fishery in Southeast Asia, with over 1 million tons of jellyfish landings and an estimated monetary business exceeding 100 million US$ (Brotz & Pauly, 2017). Consumption of jellyfish is common to most Asian Countries and often the demand overcomes the local catch; as a consequence, active jellyfish fishery is currently carried out worldwide in at least 19 Countries (Brotz & Pauly, 2017) with many companies involved in the production and import-export of edible jellyfish (http://www.trade-seafood.com/directory/seafood/jellyfish-processors.htm). In recent years jellyfishing activities have successfully established also in the Americas, with new jellyfish species exploited and exported to the Asian Countries (Brotz et al., 2017; Hsieh & Rudloe, 1994; Kitamura & Omori, 2010; Omori & Nakano, 2001). However, no significant market of edible jellyfish is still established in European Countries.

In recent years, the Mediterranean sea experienced increased proliferations of both native jellyfish and non-indigenous (or *alien*) species (Boero et al., 2016; Bosch-Belmar et al., 2016; Bosch-Belmar et al., 2017), whose outbreak-forming populations possess biochemical and textural features similar to edible Asiatic species (Leone & Piraino, 2015; Leone, Lecci, Durante, Meli, & Piraino, 2015; Leone, Lecci, Milisenda, & Piraino, 2019). The growing interest in diversification of sustainable food sources and the recent discoveries on the biological, nutritional and nutraceutical properties of several Mediterranean jellyfish species (Leone, Lecci, Durante, & Piraino, 2013; Leone et al., 2015; Leone, 2018; De Domenico, De Rinaldis, Paulmery, Piraino, & Leone, 2019) suggest the high potential of these gelatinous biomasses as local, still unexploited Mediterranean resource for biotechnological and food production sectors, in line with the latest EU recommendations and the Blue Growth strategy (European Commission, 2012).

A major challenge is the development of a jellyfish food system completely new in the Mediterranean basin, involving integrated management and sustainable exploitation of non-conventional marine biomass as food, food ingredient or for bioprospecting of any commercially valuable properties, embracing ecological, safety, nutritional, legal, economic, social and public acceptance issues. Substantiated by increasing scientific evidence, the putative healthy properties of jellyfish deals with the biological activity of proteinaceous and non-proteinaceous jellyfish components, which showed antioxidant, cancer preventive and other biological activities (Leone et al., 2013; Leone et al., 2015; D'Amico, Leone, Giusti, & Armani, 2016; Prieto, Enrique-Navarro, Li Volsi, & Ortega, 2018; De Domenico et al., 2019). Jellyfish therefore provide potential opportunity as functional novel food, once the bioactive properties will be experimentally established. However, the economic and social impact of the new putative food should be evaluated also by involvement of the potential consumers.

In this scenario, the aim of this study was to evaluate the perception of Italian consumers towards the use of jellyfish as novel food. In particular, an online survey has been carried out on a sample of 1445 citizens by administering a questionnaire specifically designed to: (I) assess the attitude of respondents towards using jellyfish as possible innovative diet ingredient, and (II) explore the effect of individual respondent characteristics (socio-demographics, personality traits, behavior habits) on the jellyfish consumption attitude (JCA).

## 2. Material and methods

### 2.1. Questionnaire

An online questionnaire was designed in Italian language using the software Qualtrics® (Provo, UT) and was administered during January to April 2018.

The survey consisted of four main parts. The first part consisted of questions on socio-demographic (gender, age, geographical area of

residence, distance in km from the nearest sea location from the place of residence, education level, occupation), socio-economic (income, number of international trips per year with a stay of more than one day, number of national trips per year with a stay of more than one day), anthropometric variables (weight and height), health status (food allergies/intolerances), and habits (smoking, food diet). Questions and answers options developed by Monteleone, Spinelli, Dinnella, Endrizzi, and Laureati (2017) were used as bases to define the questions. The second part was aimed to measure two personality related traits (food neophobia, FN; sensitivity to disgust, DS). The third part was aimed to assess the attitude towards jellyfish as animal. The last part of the questionnaire was aimed to evaluate the attitude to consume jellyfish as food itself and in relation to several food pairings and modalities of consumption.

#### 2.1.1. Personality trait measurements

Food neophobia was measured using the Italian-translated version of Pliner and Hobden's scale (1992) used for the Italian Taste project (Monteleone et al., 2017). It consists of 10 items evaluated on a 7-point Likert scale, anchored from 1 = strongly disagree to 7 = strongly agree. Once the neophilic items were reversed, the sum of the ratings for each statement was computed in order to calculate the FN value of each participant. Theoretically, this value ranges from 10 to 70, with higher values indicating propensity to neophobic behaviours and lower values to neophilic behaviours.

Core disgust sensitivity was quantified using the 8-item Short Form of the Disgust Scale (Haidt, 2004, Monteleone et al., 2017). It includes two 5-point category subscales, having for extremes 1 = strongly disagree and 5 = strongly agree for subscale 1, and 1 = no at all disgusting and 5 = extremely disgusting for subscale 2. Once reversed those needed, the sum of the ratings of each statement represents the overall score of each individual, which ranges from 8 to 40. High values indicate a tendency to feel easily disgusted.

#### 2.1.2. Measurement of the attitude towards jellyfish as food

A scale to measure the attitude to consume jellyfish as a food source (Jellyfish Consumption Attitude, JCA) was developed. FN was considered as model for the scale development. As for the FN scale, 10 statements (Table 1) were pre-determined by the authors to be evaluated by respondents on a 7-point Likert scale, with extremes 1 = strongly disagree and 7 = strongly agree.

Before evaluating this set of items, the following definition of jellyfish was presented to the respondents: *"Jellyfish are marine invertebrates and some species have been used as food for millennia in the countries of Southeast Asia but not in European countries. They are rich in protein and low in calories and could represent a sustainable seafood product, reducing the environmental impact and diversifying the fishery."*

Once the items indicating some type of rejection or fear about jellyfish (2, 3, 5, 7, 8) were reversed, the sum of items was computed for each participant, generating a JCA scale. High JCA scores indicate high proclivity to consume jellyfish as food.

Moreover, three additional questions aimed to investigate the perceived appropriateness of jellyfish as human food, the expected sensory-liking and the willingness to buy jellyfish-based food. The answer to the question *"How much appropriate for food consumption do you consider jellyfish?"* was provided on a 7-point scale (1 = strongly appropriate; 7 = strongly inappropriate). The answer to the question *"How much do you expect to like a dish containing jellyfish?"* was given on a 7-point hedonic scale (1 = extremely dislike; 7 = extremely like). The answer to the question *"How much are you willing to buy food containing jellyfish?"* was given on a 7-point scale (1 = very unwilling; 7 = very willing).

The availability to consume jellyfish-based food as related to different preparations or combinations, was investigated by the question "*How much are you willing to eat jellyfish as …*?" for a total of 13 items. Four items were related to the visible appearance of the jellyfish body (1 = whole organism; 2 = only jellyfish umbrella, without tentacles/oral arms; 3 = in pieces; 4 = as a derivative product (e.g. gelatine); three items referred to the ingredient role of jellyfish in the dish (1 = single ingredient; 2 = main ingredient; 3 = secondary ingredient); four items regarded the cooking method (1 = raw; 2 = dried; 3 = cooked – either steamed, in the oven, or sautéed; 4 = fried); two items concerned the carrier flavour of the recipe in which jellyfish could be used (1 = sweet dishes; 2 = savoury dishes). The answer was provided on a 7-point scale (1 = very unwilling; 7 = very willing).

In order to investigate the potential of jellyfish to be paired with other foods, a check-all-that apply (CATA) question was applied. The question was *"Which foods would you pair jellyfish with?"* Fourteen items were suggested: bread, beverages, dairy products and fats, fish, fruits, meat, pasta and rice, pizza and focaccia bread, potatoes, sauces, soups, sweets and snacks, vegetables, others. The order of the items was randomized across subjects.

### 2.2. Participants

A number of social media websites and in-person methods were used to recruit questionnaire participants among Italian nationals. The potential respondents were invited to participate in a 15-minute web-

**Table 1**
Items used to assess the attitude towards jellyfish as food, or Jellyfish Consumption Attitude (JCA) and results from the exploratory factor analysis conducted on 10 items (EFA 1) and 9 items (EFA 2, without the item 7).

| Items | EFA 1 | | EFA 2 |
|---|---|---|---|
| | 1 | 2 | 1 |
| 1. I would eat a jellyfish very willingly | **0.832** | 0.183 | **0.839** |
| 2. If someone offered me a jellyfish to eat, I would categorically refuse (R) | **0.824** | 0.026 | **0.833** |
| 3. At the mere idea of eating a jellyfish I would feel like throwing up (R) | **0.735** | −0.071 | **0.737** |
| 4. Jellyfish-based dishes can be very tasty | **0.605** | 0.091 | **0.609** |
| 5. Eating dishes containing jellyfish is very dangerous (R) | **0.580** | −0.513 | **0.513** |
| 6. I believe that the texture of jellyfish gives a pleasant sensation in the mouth | **0.584** | 0.208 | **0.593** |
| 7. I'm afraid of eating jellyfish because I think they can cause allergies (R) | 0.444 | **−0.494** | – |
| 8. I'm sure that if I tried a jellyfish I'd spit it right after (R) | **0.761** | −0.144 | **0.750** |
| 9. I am very interested in the idea of eating jellyfish | **0.830** | 0.225 | **0.838** |
| 10. I have no problem eating jellyfish because they are very similar to animals that I have already eaten | **0.673** | 0.211 | **0.679** |

Items for which scoring is reversed are marked (R).
Extraction method: Principal factor analysis.
Rotation method: Varimax with Kaiser normalization.
For each of the initial items a factor loading is boldfaced indicating the dimension the item is suggested to measure.

based survey distributed using a link and a QR code via email, social networks and mass media. The online survey was left active for 4 months.

A total of 1954 subjects had access to the questionnaire, but only 1517 individuals completed it. Each respondent gave his/her consent to participate in this study. The criteria for selecting participants were: Italian nationality and age comprised between 18 and 80 years. Then, a total of 1445 responses were collected and used for the analysis.

### 2.3. Data analysis

#### 2.3.1. Reliability of scales

Reliability of the FN, DS and JCA scales were assessed by calculating internal consistency (Cronbach's α), while the one-dimensionality of the scales was verified by Exploratory Factor Analysis (EFA). Correlations between items, item total correlation with JCA score and the relationship between mean values for each item and for total JCA score were measured by calculation of Pearson's correlation coefficients. The relationship between each item was further evaluated by Principal Component Analysis (PCA).

#### 2.3.2. JCA scale score segmentation

According to the subject segmentation approach used by Laureati et al. (2018) on FN scores, the JCA scale frequency was calculated and the subjects were divided into three groups based on their JCA scoring. *Low*, *Medium* and *High* groups deemed respectively for 25.3% (n = 365), 49.4% (n = 714) and 25.3% (n = 366) of the population and had a score respectively within the lowest quartile (JCA score ≤ 35, mean JCA score = 26.2), between the second and third quartiles (35 < JCA score < 52, mean JCA score = 44.0) and within the highest quartile (JCA score ≥ 52, mean JCA score = 56.2).

#### 2.3.3. Effect of subject variables on the attitude towards jellyfish

Two-way ANOVA was used to determine the main effect of gender (males, females) and age (18–30, 31–45, 46–60, 61–80), and their interaction on the variables JCA, appropriateness of jellyfish for food consumption, expected sensory-liking and willingness to buy for jellyfish.

Pearson's correlation coefficients were computed for investigating the relationships between attitude towards jellyfish (JCA, appropriateness, liking, willingness to buy), personality traits, age, distance (km) from the nearest sea location from the place of residence, and number of national trips per year with a stay of more than one day. Significance criteria was set at alpha = 0.05.

A hierarchical multiple linear regression (HMLR) was used to individuate predictors that have the greatest influence on JCA. In this analysis, the socio-demographic data (gender, age, education level) were used as a set of independent variables in step 1, in step 2 FN and DS as frequently used variables in the field of novel foods and in step 3 the Number of international trips per year with a stay of more than one day and the distance (km) from the nearest sea location from the place of residence were inserted into the regression model. By gradually inserting the predictors into the model in the mentioned order, it was possible to determine whether and to what extent the new variables, in addition to the socio-demographic data and the variables relatively frequently studied, can contribute to the prediction of the JCA. The coefficients were examined for significant differences at a significance level of 5%.

#### 2.3.4. Consumption availability for different culinary uses of jellyfish

ANOVA models were separately applied for the three clusters of subjects (*Low*, *Medium* and *High* levels of JCA) to estimate the effect of the visible appearance of jellyfish, the ingredient role of jellyfish in the dish, and the cooking method on willingness to eat jellyfish. Tukey's test (alpha risk = 0.05) was applied to highlight significant differences between mean values. *t*-test was conducted to evaluate the effect of the type of recipe in which jellyfish could be used (sweet or savoury dishes) on willingness to eat jellyfish. Significance criteria was set at alpha = 0.05.

#### 2.3.5. Effect of gender, age and attitude towards jellyfish consumption on food pairing

The occurrences of the food items of the CATA test selected for pairing with jellyfish were calculated (both as number and frequencies) for the totality of the respondent subjects, for the three clusters of subjects (*Low*, *Medium* and *High* levels of JCA) and for eight groups of subjects identified on the basis of their age and gender (males 18–30 years n = 224, males 31–45 years n = 185, males 46–60 years n = 187, males 61–80 years n = 74, females 18–30 years n = 305, females 31–45 years n = 202, females 46–60 years n = 217, females 61–80 years n = 51).

A Correspondence Analysis (CA) was carried out on the frequencies of the food items calculated for the eight groups of subjects different for age and gender.

All analyses were conducted using the XLSTAT statistical software package version 19.6 (Addinsoft, Paris, France), except for HMLR, which was performed with the software IBM© SPSS© Statistics Vers. 25.

## 3. Results

### 3.1. Characteristics of participants

The socio-demographics characteristics and health-related lifestyle behaviors of the respondents are reported in Supplementary Data – S1. The age of participants (53.6% females) ranged from 18 to 80 years, with mean age was 39.7 years (SD = 14.6) for males and 37.4 years (SD = 14.0) for females, respectively. In order to explore possible age-related differences, respondents were divided in four age groups: aged 18–30, 31–45, 46–60, 61–80 years. All the groups were not significantly different in gender. Most respondents aged 18–30 years (36.6%), and the groups aged 31–45 years (26.8%) and 46–60 years (28.0%) were similarly well represented; while the least represented group was 61–80 years (8.7%).

The distribution of respondents by residence area shows that the majority of respondents reside in Northern Italy (50.9%), and in the Southern and Islands (35.5%), while the minority (13.6%) reside in the Central area of Italy, in line with ISTAT data on the residence areas of the Italian population (ISTAT, 2011). The 27.4% of the respondents were regular or occasional smokers. Most participants (85%) reported no food allergy and/or intolerance.

### 3.2. Reliability of food neophobia and disgust sensitivity scales

Satisfying internal consistency was found for both FN and DS scale, with Cronbach's alpha equal to 0.873 and 0.719, respectively. Results of the factor analysis showed that all items of each scale mainly correlated to the first factor with loading values ranging from 0.527 and 0.754 and from 0.276 to 0.677 for FN and DS, respectively.

### 3.3. Reliability of jellyfish consumption attitude (JCA)

Very good internal consistency (Cronbach's alpha = 0.896) was found for the JCA scale, whose items were all positively and significantly correlated ($p < 0.0001$). However, loading scores resulted from the exploratory factor analysis (Table 1) shown that nine items out of 10 described the first dimension while item 7 described the second dimension. Thus, a second exploratory factor analysis was performed excluding item 7. Results demonstrated that the nine-item scale was one-dimensional, thus further analysis were conducted excluding item 7 and a JCA score was calculated on the basis of the other nine items. Cronbach's alpha calculated for the reduced JCA scale slightly

**Table 2**
Effect of gender and age on the attitude towards jellyfish (Jellyfish Consumption Attitude, JCA; jellyfish as food appropriateness; expected liking for jellyfish as food; willingness to buy jellyfish).

| Variable | Range | Mean | SD | Median | Gender | | | | Age | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Males | Females | F | p-value | 18–30 | 31–45 | 46–60 | 61–80 | F | p-value |
| JCA | 9–63 | 42.6 | 11.9 | 44.0 | 44.8[a] | 40.7[b] | **43.27** | **< 0.0001** | 43.8[a] | 42.7[ab] | 41.4[ab] | 40.9[b] | **5.26** | **0.0013** |
| Appropriateness | 1–7 | 4.8 | 1.6 | 5 | 5.0[a] | 4.6[b] | **28.12** | **< 0.0001** | 5.0[a] | 4.8[ab] | 4.5[b] | 4.5[b] | **10.22** | **< 0.0001** |
| Liking | 1–7 | 4.2 | 1.5 | 4 | 4.5[a] | 4.0[b] | **29.83** | **< 0.0001** | 4.4[a] | 4.2a[b] | 4.1[b] | 4.0[b] | **8.06** | **< 0.0001** |
| Buy | 1–7 | 4.0 | 1.8 | 4 | 4.3[a] | 3.7[b] | **41.51** | **< 0.0001** | 4.4[a] | 3.9[b] | 3.7[b] | 3.6[b] | **16.49** | **< 0.0001** |

Different letters indicate a significant difference between genders or among age groups, respectively.
F and p values in bold are significant.

increased (0.901) and the nine items were all positively and highly significantly correlated ($p < 0.0001$). Pearson's correlation coefficients ranged from 0.248 to 0.851 and the total correlation with JCA scale score ranged from 0.577 for item 5 and 0.851 for item 1. PCs explained 66.78% of the total variability, with PC1 deeming 56.55% and PC2 10.23%, and showed that the correlation among items was positive on PC1. Moreover, PC2 separated reversed (positive correlation) from unreversed items (negative correlation), indicating the ability of the instrument to measure two distinctive dimensions that describe opposite reactions to jellyfish.

### 3.4. Effect of gender and age on the attitude towards jellyfish

A gender effect was found for all variables (Table 2). Males exhibited significantly higher scores than females for their JCA, appropriateness, expected sensory-liking, and willingness to buy.

Also, an effect of age was found for all considered variables. Attitude towards jellyfish consumption, appropriateness, expected sensory-liking and willingness to buy decreased as the age of respondents increased. The interactions between Gender × Age were not significant.

### 3.5. Relationship among attitude towards jellyfish, personality traits and age

Significant correlations between JCA, FN, DS and age were found (Table 3) considering the totality of the subjects. JCA values were negatively correlated to FN and DS, which were positively correlated with each other, indicating that neophobic behaviour and propensity to be easily disgusted may represent a barrier to accept the idea to consume jellyfish. A significant weak negative correlation was found between JCA and age, indicating a tendency of younger respondents to have a higher attitude towards jellyfish consumption than older respondents. Age was also positively correlated to food neophobia and sensitivity to disgust, which are both negatively correlated to JCA.

A HMLR was performed to assess the effect of gender, age, education level, FN, DS, the Number of international trips per year with a stay of more than one day, and the Distance (km) from the nearest sea location from the place of residence on JCA (Table 4). The inclusion of age, gender, and education level in the first step of the analysis was significant, $R^2 = 0.059$, $F(3, 1441) = 30.03$, $p < 0.001$. The addition of FN and DS variables in the second step resulted in a large significant increase in $R^2$, $\Delta R^2 = 0.318$, $\Delta F(2, 1439) = 367.81$, $p < 0.001$. The final step resulted in a slight significant increase in $R^2$, $\Delta R^2 = 0.005$, $\Delta F(2, 1437) = 5.33$, $p = 0.005$. The overall model was significant, $R^2 = 0.382$, $F(7, 1437) = 126.79$, $p < 0.001$ and explained 38% of the variance in JCA. FN was the strongest negative predictor of JCA ratings, $\beta = -0.40$, $t(1437) = -17.76$, $p < 0.001$. DS was also a negative predictor $\beta = -0.29$, $t(1437) = -12.47$, $p < 0.001$. These findings indicated that lower levels of FN and DS were associated with increased attitude to jellyfish consumption. Gender, age and the distance (km)

**Table 4**
Hierarchical multiple regression models explaining the attitude towards jellyfish as food, or jellyfish consumption attitude (JCA; n = 1445).

| JCA | Variable | B | SE B | β |
|---|---|---|---|---|
| Step 1 | Costant | 47.69*** | 1.57 | |
| | *Gender* | −4.45*** | 0.61 | −0.19 |
| | *Age* | −0.11*** | 0.02 | −0.13 |
| | *Education level* | 1.43*** | 0.26 | 0.15 |
| Step 2 | Costant | 69.50*** | 1.57 | |
| | *Gender* | −1.97*** | 0.52 | −0.08 |
| | *Age* | −0.01 | 0.02 | −0.01 |
| | *Education level* | 0.89*** | 0.21 | 0.09 |
| | *FN* | −0.43*** | 0.02 | −0.41 |
| | *DS* | −0.59*** | 0.05 | −0.29 |
| Step 3 | Costant | 69.20*** | 1.79 | |
| | *Gender* | −1.83*** | 0.52 | −0.08 |
| | *Age* | −0.01 | 0.02 | −0.01 |
| | *Education level* | 0.74*** | 0.22 | 0.08 |
| | *FN* | −0.42*** | 0.02 | −0.40 |
| | *DS* | −0.59*** | 0.05 | −0.29 |
| | *International_trips* | 0.81** | 0.36 | 0.05 |
| | *Distance from the sea* | −0.44** | 0.17 | −0.05 |

*Note*: $R^2 = 0.059$ for Step 1 ($p < 0.001$), $\Delta R^2 = 0.318$ for Step 2, $R^2 = 0.377$ for Step 2 ($p < 0.001$), $\Delta R^2 = 0.005$ for Step 3, $R^2 = 0.382$ ($p = 0.005$). * $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

**Table 3**
Pearson correlation coefficients within the attitude towards jellyfish (jellyfish consumption attitude, JCA; jellyfish as food appropriateness; expected liking for jellyfish as food; willingness to buy), personality traits (food neophobia, FN; sensitivity to disgust, DS) and age.

| Variables | JCA | Appropriateness | Liking | Buy | FN | DS | Age |
|---|---|---|---|---|---|---|---|
| *Total (n = 1445)* | | | | | | | |
| JCA | **1** | | | | | | |
| Appropriateness | **0.72** | **1** | | | | | |
| Liking | **0.78** | **0.71** | **1** | | | | |
| Buy | **0.83** | **0.70** | **0.76** | **1** | | | |
| FN | **−0.53** | **−0.38** | **−0.42** | **−0.49** | **1** | | |
| DS | **−0.46** | **−0.36** | **−0.37** | **−0.44** | **0.35** | **1** | |
| Age | **−0.09** | **−0.14** | **−0.11** | **−0.16** | **0.12** | **0.19** | **1** |

Pearson correlation coefficients in bold indicate a significant correlation ($p < 0.05$).

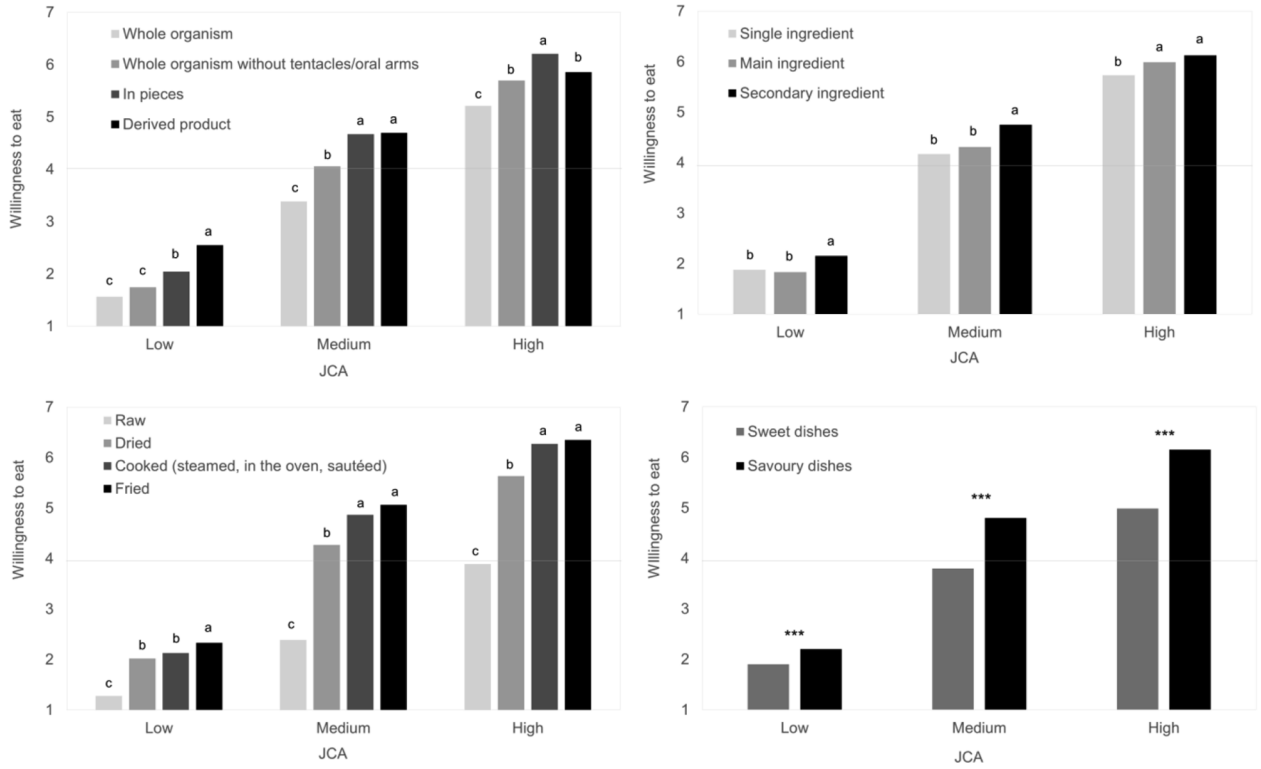


**Fig. 1.** Effect of the visible appearance (A), ingredient role (B), cooking method (C) and carrier flavour of the recipe (D) on the willingness to eat jellyfish by subjects with *Low*, *Medium* and *High* attitude towards jellyfish as food. Different letter within a cluster indicate a significant difference between the means of each modality of consumption (Tukey's test, $p < 0.05$). *** $p < 0.001$ (*t*-test).

from the nearest sea location from the place of residence resulted weak negative predictor of JCA. On the contrary, the education level and the number of international trips per year with a stay of more than one day resulted weak positive predictors of the attitude to jellyfish consumption.

### 3.6. Consumption availability for different culinary uses of jellyfish

The consumption availability of jellyfish as a function of different culinary uses, was investigated by ANOVA and *t*-test for the three JCA clustered levels of respondents (*Low*, *Medium*, *High* JCA) (Fig. 1). Clusters *Low*, *Medium* and *High* showed significantly differences for each variable ($p < 0.0001$), with the cluster *High* giving higher values, compared to the *Medium*, which in turn expressed higher values than the cluster *Low*. In particular, respondents belonging to JCA cluster *Low* were never available to consume jellyfish as food (mean values lower than the central value of the evaluation scale, 4), while cluster *High* declared to be available to consume jellyfish for all conditions (mean values higher than the central value of the evaluation scale, 4), except for raw jellyfish.

A strong effect of the visibility of the jellyfish on consumption availability was noticed within each subject group. For the cluster *Low*, the consumption availability significantly increased as the recognisability of the animal decreased (whole organism < whole organism without tentacles/oral arms < in pieces or derived product). A similar raising trend was observed for the cluster *Medium*. Indeed, the average scores of consumption availability for the jellyfish in pieces and the derived product were stated higher than the central value of the scale and were not significantly different from each other. For cluster *High*, the highest value was obtained for the jellyfish in pieces, while not significant differences of consumption availability were found between the whole organism without tentacles/oral arms and the derived product.

Concerning the ingredient role of jellyfish in a recipe, the clusters *Low* and *Medium* provided a consumption availability for the use of jellyfish as secondary ingredient significantly higher than for its use as single or main ingredient. For the cluster *High*, the uses as main or secondary ingredient resulted similar to each other and higher than the use as single ingredient.

Among the cooking methods, the Cluster *Low* showed the highest availability consumption for the fried jellyfish and cooked in different ways (steamed, in the oven, and sautée), followed by similar average scores obtained for the jellyfish for dried jellyfish. For the clusters *Medium* and *High*, the consumption availability increased from dried to cooked (steamed, in the oven, and sautée) and fried jellyfish, with all values above the central point of the evaluation scale. For all clusters, the raw jellyfish obtained the lowest average score, which was in all cases below the central value of the scale.

A *t*-test was carried out to compare the consumption availability declared for savoury or sweet dishes, revealing a significant effect of the type of recipe for all three clusters. In particular, the savoury dishes always obtained higher scores of consumption availability than the sweet dishes. Moreover, for the cluster *Medium* the savoury recipes received an average score higher than the central point of the evaluation scale while the sweet dishes did not.

### 3.7. Food pairings

With respect to the totality of the respondent subjects, the number of food items selected for matching with jellyfish was in average 3.34 (SE = 0.05) and ranged from 1 to 14 (corresponding to the total number of items included in the CATA list). Taken into account the three JCA clusters, the mean number of selected items was 2.14 (SE = 0.08), 3.37 (SE = 0.07), and 4.50 (SE = 0.12) for clusters *Low*, *Medium* and *High*, respectively. The range of selected items was limited (1–8) for the *Low* cluster, wider (1–13) for cluster *Medium*, and corresponding to the maximum possible (1–14) for cluster *High*.

The percentage frequencies of selection of foods for pairing with

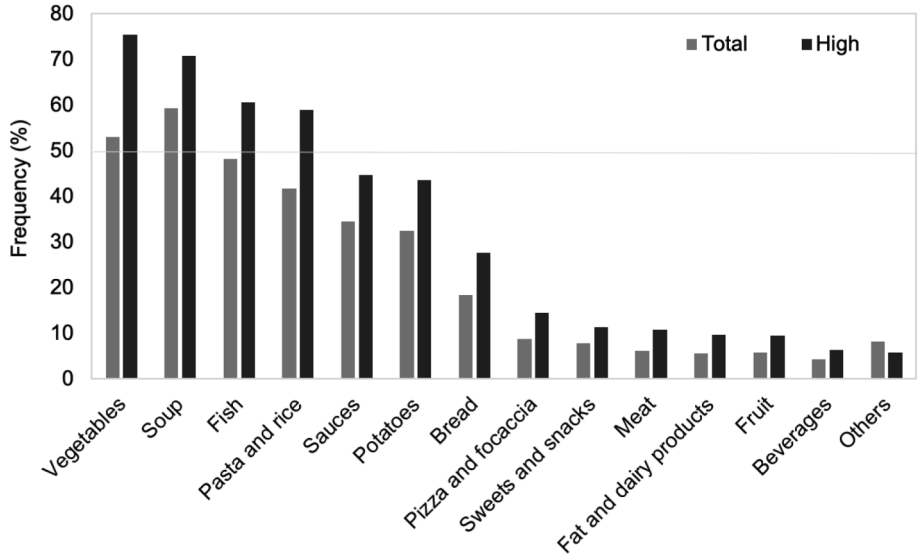


**Fig. 2.** Foods pairing with jellyfish optioned by the totality of the respondents and by the cluster with high attitude towards jellyfish consumption. The frequencies of choice is reported as percentages in the chart. Number of respondents (n) are reported as total (n = 1445) and high (n = 366) JCA.

jellyfish by the totality of the subjects and by the clusters with a high attitude towards jellyfish consumption are reported in Fig. 2. The top pairing selections were soups, vegetables, fish, pasta and rice, sauces, and potatoes, for the totality of subjects. In particular, soups and vegetables were chosen by more than half of the subjects, while less than 10% of the subjects would pair jellyfish with pizza and focaccia bread, sweets and snacks, meat, fruits, dairy products and fats, beverages. Finally, 8.2% of the subjects declared to be available to pair jellyfish with other foods not included in the CATA list. With regard to the cluster *High*, the range of food selection frequency was 6.0–72.7% and high occurrence of selection (42.4–72.7%) was found for several items, indicating a remarkable availability of this group in consuming jellyfish matched with various categories of food. The two preferred selections (soups, vegetables) were chosen by about three quarters of the members of the cluster *High*.

A Correspondence Analysis (CA) ordination diagram (Fig. 3) shows the relationships between the selection of foods paired with jellyfish and the eight subgroups of respondent subjects, split by gender and age group and belonging to cluster *High*. The total inertia explained by the CA plot of two-dimensional coordinates for foods pairing with jellyfish was 74.2%, with Dim1 and Dim2 accounting, respectively, for 42.9% and 31.3%. Groups of subjects are distributed along Dim1 mainly as a function of the gender, with males on the left side and females mostly on the right side of the map. Females would prefer to pair jellyfish with sweets and snacks, vegetables, pasta and rice, and potatoes. On the contrary, males would match jellyfish preferably with pizza and focaccia bread, meat, and fruits. Moreover, the female groups are distributed along Dim1 also as a function of the age class, which the highest age class positioned on the very right side of the graph. Dim2 discriminates the oldest age class for both gender groups. It seems that females and males with age ranging between 61 and 80 years tended to associate jellyfish to pizza and focaccia bread, and beverages more than younger respondents.

## 4. Discussion

### *4.1. Socio-demographics, anthropometric variable and personality traits influence the attitude towards jellyfish*

In this study, the most relevant factors influencing the attitude of respondents towards jellyfish resulted gender, age, personality traits, habit to internationally travel, the geographical area of residence, and the educational level.

A strong effect of gender on the attitude towards jellyfish was observed, with mean scores of all variables related to jellyfish (JCA, appropriateness of jellyfish as food, expected sensory-liking and willingness to buy jellyfish products), with higher values for males than female respondents. This result is in agreement with the studies reporting a gender effect on the acceptability of other non-traditional or "exotic" foods like insects (Megido et al., 2016; Tan, van den Berg, & Stieger, 2016). This could be partially explained taking into account that men are generally more explorative than women, thus more prone to taste unusual foods (de Boer, Schösler, & Boersema, 2013). Similarly, an effect of age was also found for JCA, jellyfish as food appropriateness, expected sensory-liking and willingness to buy jellyfish, showing mean scores tend to decrease with age. This result confirmed that older generations are generally more conservative in their food choices in comparison to the younger generations, who tend to be more open-minded and proclive to novel food experiences (Tan et al., 2016; Verbeke, 2015).

FN and DS scores resulted negatively correlated to JCA values and positively correlated to age for the totality of the respondents, and for males and females separately. This result confirmed several previous studies highlighting that food neophobia and sensitivity to disgust are negatively associated to the acceptance of unfamiliar foods (Tuorila, Lähteenmäki, Pohjalainen, & Lotti, 2001; Choe & Cho, 2011), indicating that those personality traits in both genders could be an important barrier to the hedonic acceptability of jellyfish. Interestingly, FN has been also found to be positively associated to lower dietary quality and higher body mass index in adults (Knaapila et al., 2015); comparably, FN was found significantly higher in obese adults than in healthy weight subjects (Proserpio, Laureati, Invitti, & Pagliarini, 2018). In this framework, preliminary information corollary to this survey (data not shown) encourages to further investigate the underlying mechanisms linked to potential negative correlation between JCA and nutritional status of respondents.

Characterization of JCA clustered groups revealed that a great importance was associated to the number of international travels per year. Indeed, the Low JCA cluster included a higher proportion of subjects who declared they did not undertake any international trip per year with a stay of more than one day, whereas High JCA cluster included people travelling more than once per year both at international and national level. It could be hypothesized that people spending more time abroad have more opportunities to taste foods belonging to different

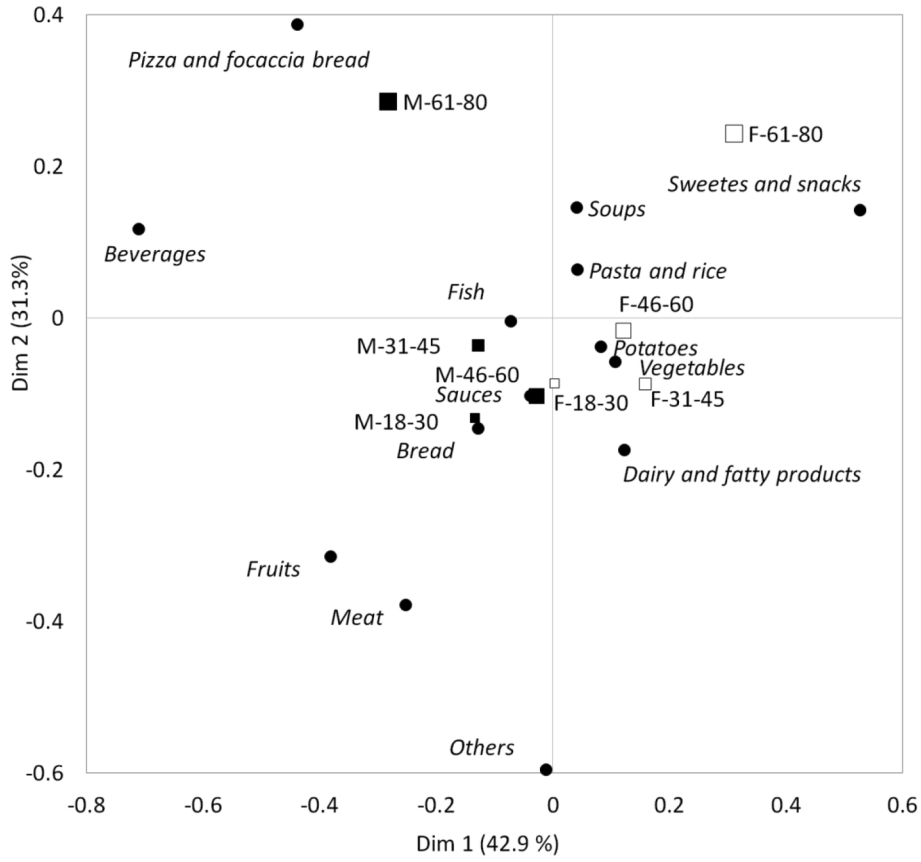


**Fig. 3.** Correspondence Analysis ordination diagram relating the choice of the foods potentially paired to jellyfish to eight groups of respondents belonging to cluster High, based on gender (M = males, F = females) and age (18–30, 31–45, 46–60, 61–80).

dietary cultures, thus probably also to exotic and novel foods. Exposure to unfamiliar foods, different from the traditional ones of the own country of origin, may promote openness to other food habits and novel foods. de Boer, McCarthy, Cowan, and Ryan (2004) showed that many consumers have become more adventurous and required authentic non-traditional meals as a consequence of frequent traveling abroad. Similarly, the number of trips taken outside the country of residence negatively affected food neophobia level (Olabi, Najm, Baghdadi, & Morton, 2009).

An important factor in increasing the attitude towards jellyfish was the area of residence, with people living on islands having higher JCA values. Inhabitants of islands are certainly more familiar with the sea and the marine organisms; thus, a more positive attitude towards jellyfish as animal it reasonably expectable, much more than by individuals being unfamiliar with the sea environment. Indeed, since the three *Low*, *Medium*, *High* JCA clustered groups were associated to three significant levels of jellyfish-as-food appropriateness, expected sensory-liking and willingness to buy, it seems that a high attitude to jellyfish as animal may promote the hedonic shift for the acceptance of jellyfish foods. The higher potential of jellyfish as food source for consumers living on islands could be also related to the consumers' preference for local or domestic over foreign products (Feldmann & Hamm, 2015; Grebitus, Lusk, & Nayga, 2013) a trend identified also for seafood (Claret et al., 2012; Risius, Janssen, & Hamm, 2017). The perception of jellyfish as sustainable food resource could also drive food preference (Zander & Feucht, 2018). Since the ecological conditions of a society are expected to have a substantial effect on food production and consumption, the perception of jellyfish as a sustainable food and as a product originated by a local resource of specific territories and geographical areas could drive favorable promotion of jellyfish consumption willingness.

### 4.2. Factors influencing the culinary use and food pairing of jellyfish

This study revealed that the willingness to eat jellyfish was strongly influenced by the modalities of using and preparing the product. Even if some differences among the individuals with *Low*, *Medium* and *High* JCA cluster levels were observed for all the considered variables, the cluster High well illustrates some commonalities. The visibility level played an important role in determining the willingness to eat jellyfish, indicating that the whole organism (with or without tentacles/oral arms) was less acceptable than the derived product or the product in pieces. This result was in agreement with previous research (Tan et al., 2016) on a different type of novel food (mealworm larvae), indicating that products with visible mealworms were rated more negatively than products with invisible worms across all measures of acceptability (product appropriateness, expected sensory-liking, willingness to buy, and willingness to try). Similarly, Stock, Phillips, Campbell, and Murcott (2016) concluded that the acceptance of insects as food requires production of non-visible insect formulations (e.g. flours). Moreover, the ingredient role of the jellyfish in the dish preparation and the cooking method resulted very important variables affecting the willingness to eat the product. In particular, in agreement with Tan et al. (2016), the savoury carrier flavour of the recipe obtained more positive willingness to eat scores than sweet dishes.

Food pairing is aimed at identifying which foods go well together (www.foodpairing.com). Over the last two decades, the method of matching foods/ingredients to obtain new combinations with

promising results in terms of sensory food experience is attracting more and more interest. Recently, consumers' palates have evolved to eat much more adventurously than before, with unexpected ingredient combinations becoming the new norm. Thus, it seemed extremely relevant to investigate the potential of jellyfish in food pairing, particularly for the Italian population. Indeed, even if food pairing was defined as by the standard concept that ingredients with similar flavor constituents taste well when combined in a recipe (Blumenthal, 2008), different dietary cultures may have different concepts of food pairings: thus, food pairing is likely a culturally- (and cuisine-) specific process (Lahne, 2018; Torri, Jeon, Piochi, Morini, & Kim, 2017). Ahn, Ahnert, Bagrow, and Barabási (2011) found that Western cuisines show a tendency to use ingredient pairs that share many flavor compounds, whereas East Asian cuisines tend to avoid compound sharing ingredients. Thus, very different results of food pairing could be obtained from subjects from different gastronomic cultures and countries. It could be hypothesized that in the Mediterranean countries, and particularly in Italy, home country of the Mediterranean Diet, the sensitivity to novel foods could be stronger than in Countries where the cultural identity is not so strongly linked to traditional foods. However, globalizations of consumers and the tendency to the creative use of different elements in the "fusion foods" in the high quality gastronomy, gradually affected this diet model. Nowadays modification of local resources, climate change, and social migrations are triggering the "diversification" of food habits and the transformation of the cultural identity of citizens.

Moreover, our findings refer only to expected sensory-liking data, not to situations including real consumption of the food matches. Cardello, Schutz, Snow, and Lesher (2000) highlighted that consumers' reports of expected food liking could be poor predictors of simulated meal situations. Thus, it will be worth to verify our results with sensory tests, including the real consumption of a selection of the jellyfish matches proposed in this study.

This study has a few limitations: the scale used to estimate the attitude towards jellyfish as food was not validated on a second sample of subjects, and the data were collected by a sample of volunteers, engaged mainly by social media, that decided to participate to the study, so the subjects were not randomly selected among the Italian population. Respondents who decided to fill in the survey were maybe subjects interested to the topic, likely more positively oriented towards jellyfish in comparison to subjects who decided to skip the survey. Consequently, the obtained JCA values could be slightly overestimated.

## 5. Conclusion

The present study provided insights into the perceptual differences that underlie the evaluation of jellyfish as potential food of the future in western Countries. The questionnaire to explore the perception of jellyfish among the Italian population and a scale developed *ad hoc* to assess the relative attitude toward jellyfish as food, resulted suitable to identify the effect of the subjects' characteristics on their acceptability of jellyfish as novel food. This work indicates that food neophobia and sensitivity to disgust are confirmed as personality traits able to influence the acceptability of a novel food, like jellyfish. In addition, our findings indicated that people having higher propensity to accept jellyfish are young individuals, familiar with the sea environment, with high education level or students, and frequent travellers. Overall, this work provided insights into the acceptance and rejection variables that would be taken into account when promoting a novel food within a culture not used to consider it as food. Although with the above exposed limitations, this is the first study on the perception of jellyfish as possible food in a Western Country and, at our best knowledge there is no similar study among Eastern consumers. The findings here exposed could help to drive both future research and stakeholders involved in the food production, to better move toward a future jellyfish food system.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.foodqual.2019.103782.

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