Senior Consumers Involvement in Developing New Fish-Based Foods Through Dequential Hedonic Tests

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Abstract

Older population needs specific food, adequate to age and health requirements, and acceptable from the sensory point of view. To develop functional products the involvement of senior assessors was experimented. A panel of 35 seniors evaluated fish-burgers and fish-sausages through sensory tests adapted to their cognitive capacities. A model of sequential discrimination, ranking and tetrad tests, was applied with the aim to define the shape (burger vs. sausage), The species and relative percentage of fish, the addition of vegetables, and the presence of potato. The panel indicated a preference for sausage, while ranking tests indicated tuna alone or with mackerel to be preferred. The addition of tomato and artichoke improved acceptance. The acceptance scores showed that progressive discrimination tests successfully supported the development products. This study focusing on age related sensory perception, demonstrated how elderly are able to perform not only simple paired comparisons, but also more demanding ranking tests. There are mainly two practical applications in this work: a methodological one and an applicative one. The methodological is related to the evidence that quite complex and up to date sensory studies, if well structured, can be correctly executed by elder consumers. The applicative output is a preliminary recipe of healthy food for elder people that can be used as milestone in future studies.

Introduction

An adequate nutrition for older population is presently a major social challenge. Malnutrition can be tackled through the design of specific food, suitable to age and health requirements. However, *to* motivate regular food consumption, appropriate for nutritional requirements, also hedonic expectations of mature consumers should be satisfied[1,2]. Thus, effectual

novel-food development would integrate functional properties with the study of sensory perceptions correlated to food appreciation. Feeding occupies the first place among human essential needs and the nutrients that guarantee life are provided to the body by foods. Human beings are not naturally led to follow a balanced diet and only in the few decades, the nutrition science has established the rules on how to provide to the body all the nutrients it needs. A proper diet always has a positive effect on health status and hence the quality of life; this applies in particular for the elderly and their dietary requirements which are influenced by age-related changes. Elderly people should follow a balanced and complete diet especially in the main nutrients. Food choice must not be based on acquired habits, but rather on the impact that foods exert on health and physical efficiency. The improperly eating of senior undergoes both a quality and quantity errors. Firstly, in terms of absence, insufficient or excessive consumption of some foods to the detriment of others and secondly, excess or defect supply compared to the energy needs. Moreover, the elderly diet often does not include certain healthy foods as fish, meat, vegetables and fruit. Thus, older people frequently show nutritional deficiencies related to several factors as low-income or lack motivation/ability to cook. In nature there is no food that contains all the nutrients, therefore it is necessary to alternate the different foods during meals or consume balanced products.

Food designed for elderly should ease manipulation, chewing and swallowing[3,4,5] and cope with reduced appetite through nutrient dense foods[6,7]. A commonly reported nutritional problem for older adults is the lack of proteins, which are key factors to limit and treat age-related declines in muscle mass, strength, and functional abilities[8,9] .Fish is considered an excellent source of protein with low saturated fat, nutritious trace elements, long-chain omega-3 polyunsaturated fatty acids (LCn3PUFAs), and vitamins D and B[10,11]. A comprehensive meal, suited for older people, should include fibers and carbohydrates. In the first case, the consumption of larger quantities of fibers should avoid constipation, which represents a common complaint of ill or inactive elderly people[12], and may contribute to restore normal bowel function. Whilst, as reported by Kaplan *et al.*,[13] dietary carbohydrates as well as potatoes and barley, improve memory performance and enhanced cognition, similarly

to glucose, in elderly subjects with relatively poor memories or poor â cell function. Importantly, the carbohydrate-containing foods stimulate effects that were independent of their effects on plasma glucose. Thus, it is important to offer products that meet nutrient recommendations for elderly people.

To fully express its potential benefit, a functional food should meet elderly population nutritional needs, without spoiling hedonistic issues. In facts, eating pleasure is acknowledged as an essential component in the regulation of food intake[14]. Eating behavior is affected by psychological, social and physiological modifications occurring with age[15,16], including alterations of sensory sensitivity[17] that affect food choices[18]. *Therefore, to develop prized functional products the involvement of senior assessors, representative of older population in terms of acuity and hedonic choices is important,* since their perceptions may differ substantially from those of adults who are under 60 years of age[19]. The involvement of elder people requires a careful planning of sensory tests, taking into account possible physical and physiological impairments and cognitive status[20]. As related to discrimination tests, researches on the perception threshold, showed elderly ability in performing 2-AFC or 3-AFC type tasks[21]. A recent review[2] recommends choosing duo–trio tests, or paired comparison tests, rather than a triangle test or tetrad, due to the number of samples, more demanding from a cognitive point of view. The authors did not found studies conducted with elderly through ranking tests. Descriptive test is a more demanding task, but positive results have been recorded with older people[18].

The aim of this research was to develop a nutritionally complete foodstuff, based on fish, with the addition of ingredients enhancing healthy properties. To the aim, a step-by-step development of high nutritional fish-based food was carried out by involving older assessors in different discrimination and ranking tests. The abilities to use hedonic scale to rate appreciation and to perform simple descriptive tasks were also assessed.

Materials And Methods
Raw material
Three different kinds of frozen fish were used for the preparation of fish burgers and sausages. In particular, tuna (*Thunnus albacares*), swordfish (*Xiphias gladius*) and mackerel (*Scomber scombrus*)

were kindly provided by a local fish company (Minaba, Manfredonia, Italy). Once at the laboratory, fish were thaw out, filleted and skinned for the fish burgers or sausages preparation.

Samples preparation

A novel food, adequate to elderly needs in terms of eating task (handling, munching, swallowing) and basic nutritional elements (size, proteins, healthy fats, such as omega-3 and omega-6 fatty acids derived from extra-virgin olive oil and fish, respectively, fiber and carbohydrates) was designed. The products were developed by following different steps to balance both nutritional and sensory properties. The initial food prototypes with tuna minced fish (60%), eggplant (20%, semi-dried) and different spices (20%) were optimized in the laboratory of University of Foggia and then, fish-burgers and fish-sausages (40g) were properly prepared by mixing these ingredients for the first test with older assessors. Further recipes were then tested by varying fish species (tuna, swordfish, chub mackerel), vegetables (eggplant, artichoke, tomato) and by adding minced potatoes (section 3.2 and 3.3, respectively). In particular, samples were prepared by mincing skin-off fillets with an industrial food processor (Everest, Rimini, Italy). Semi-dried vegetables (eggplant, artichoke, tomato) (8 g) (Farris, Foggia, Italy) were added to minced fish (23 g) containing salt (0.2), parsley (0.2 g), potatoes starch (3 g) and oregano (0.2 g), the latter was added only in the recipe with tomatoes. Moreover, a proper whey protein foam (1.6 g) (Farmalabor, Canosa di Puglia, Italy) prepared according to a methodology developed by Conte et al.,[22] was soaked with extra-virgin olive oil (4 mL) and added to the formulation. All the ingredients were homogenized in a bowl mixer (Multichef Ariete, Firenze, Italy) with a spiral dough hook for 5 min. The obtained fish dough was used for both burgers and sausages preparation. In particular, burgers were prepared by hand (40 g, 30-40 mm diameter), while sausages were bagged with a tool (O.M.R.A., Rimini, Italy) into a gut of lamb. All samples were steam cooked in electric oven for 20 min at 240 degrees centigrade.

Assessors

The acceptance of the new functional ready-to-cook fish-food was assessed by sensory tests on elderly people. The number of ingredient to be taken into account and combined (shape, type of fish and vegetable, presence of potato starch) was not compatible with a reasonable effort of products' testing by participants in a single session. Sequential sessions of tests were then planned taking into account the effect of aging, potentially decreasing the working memory of participants, and monitoring participant performances[2].

A panel of 35 seniors, 18 female and 17 male; 65-85 years, independently living, autonomous in food choice and preparation, was involved in food evaluation. No specific training was provided since the aim was to get a hedonic evaluation, but the panel participated on a 3-week basis, to a series of sensory tests of increasing difficulty. The purpose was to get hedonic judgements while assessing how common sensory tests were adequate to cognitive capacities of participants. Assessors shared tables but seated separately to prevent bias. For the tetrad tests 53 assessors were involved; only hedonic

Table 1: Paired comparison test: fish-burger vs. fish-sausage and attributes driving the preferences

| Preparation | Liking | | Attributes driving preference (%) | | | | |
	Preference	Average (%)	Appearance Rating (1-9)	Odor	Taste	Juiciness	Tenderness
Sausage	69	6.8	40	29	63	11	29
Burger	31	6	20	14	23	11	26
No choiche	0	-	40	57	14	78	45
p	*	*	n.s.	n.s.	*	n.s.	n.s.

*indicate significant differences among preparations (p 0.05; n.s: non significant).

assessment of judges correctly executing tetrad test were taken in account.

Hedonic tests

A model of sequential discrimination tests of increasing effort for elderly cohort was applied. The first test was a paired comparison, the two samples had the same composition, while differing for preparation as burger or sausage. To ease task execution, participants received the two samples inside coded vessels, and they were requested: 1) to taste both samples; 2) to place the vessel containing the preferred into dishes placed in front of them labelled as "migliore" (the best), "peggiore" (the worst), to familiarize with the best-worst scaling[23]. An operator took care of writing down sample labels and, referring to best or worse sample, ask for a 1-9 acceptance score, and finally for selected attributes driving individual preference. Three successive tasting sessions, in different days, were performed, each proposing a best-worst ranking test on three products: (a) fish species: tuna, swordfish, chub mackerel; (b) different tuna-chub mackerel percentages (100-0%; 70-30%; 60-40%);

(c) vegetables enrichment: hedonic comparison of tomato, eggplant or artichoke addition. The best-worse protocol was performed on the three samples (the remaining sample ranked second).

A final session included two tetrad tests on fish sausage: I) tomato flavored, with or without potato; II) artichoke flavored. The assessors were requested to make pairs of identical samples, than, as usual, to place vessels (pairs) into "best" or "worse" labelled dishes.

Statistics

Data were analyzed by SAS System Software 9.4 (SAS Institute, Inc., Cary, NC, USA) and R version 3.3.1 with SensR package for sensory discrimination analysis (2-AC and Tetrad test). For multiple-sample comparison based on ranks, the Friedman rank sum test was used. Cochran's Q test is used to evaluate if consumers detected significant differences among samples for each of the terms from the CATA question. The consumer hedonic ratings were analyzed using univariate statistics. Analysis of variance (ANOVA) was performed to assess differences in acceptance among the samples and means were compared using Duncan's Multiple Range Test.

Results And Discussion
Paired comparison

The comparison test on fish-burger vs. fish-sausage indicated a clear preference of older panel for fish-sausage as compared to fish-burger. Preference was recorded through paired comparison and confirmed by hedonic rating (Table 1). Appearance, odor, taste, juiciness and tenderness were the sensory attributes to be evaluated. Among these attributes, "taste" resulted the only significant one orienting the preference.

Table 2: (a) Products ranking: tuna vs. swordfish vs. chub mackerel

Fish	Average Ranking (3:best; 1:worst)	Best (%)	Average Rating (1-9)
Tuna	2.2	48	6.1
Swordfish	2	29	6.1
Chub mackerel	1.8	23	5.7
p	*	*	*

*indicate significant differences among preparations (p ≤ 0.05).

Table 2: (b) Attributes driving the preferences

Fish	Attributes driving preference (number of citations)				
	Appearance	Odor	Taste	Juiciness	Tenderness
Tuna	8	5	13	3	6
Swordfish	7	7	13	4	5
Chub mackerel	0	2	5	2	2
Total	15	14	31	9	13

Products ranking

Fish belongs to the class of foods rich in proteins with high nutritional value, iron and vitamins (group B and A), particularly suitable for its digestibility. Inside a balanced diet, the protein requirement represents about 15% of total calories. The proteins have "constructive" function and therefore are used for the formation of cells, tissues and for their continuous replacement. In particular, they consist of several simple elements called amino acids; some of them are essential because the human organism is not able to produce them and must be necessarily introduced with food. Among the different available forms, the proteins from animal source are characterized by the highest biological value, due to their essential amino acids contents. Fish is characterized by protein composition of high biological value (even up to 20% by weight), therefore more digestible and better usable for protein synthesis. Thus, the developed product is an excellent food for everyone, but especially for elderly people.

In order to identify the fish matrix most suited to produce fish-based ready-to-cook meals, samples were prepared by using *tuna, swordfish and chub mackerel.* Besides the different organoleptic characteristics of the proposed fish matrixes, also the nutritional properties should be considered. In fact, fish composition is not constant, since it depends on many factors, such as species, age, sex, environment, diet, and season capture. In particular, the lipid content and the fatty acid composition were the components which showing the greatest variation[24,25,26].

The tables 2a and 2b show the first products ranking test focused on the fish selection. In particular, ranking test showed a preference for tuna and swordfish as compared to chub mackerel (table 2a). Results were confirmed by rating. However, tuna was ranked "best" at a significant higher frequency. Among attributes orienting preference, "taste" resulted the most cited, especially for tuna and swordfish (table 2b). Different tuna-chub mackerel percentages were reported in Table 3a and 3b. The previous test showed chub mackerel (CM) being the less appreciated, but since its composition improves product nutritional value due to the excellent amino acids composition of its muscles and the content of nutrients and easily digestible protein[27], different percentages were tested in combination with tuna. Moreover, ranking test confirmed the high appreciation for tuna sausage, but identical evaluations were recorded also when chub mackerel was present at 30%. The increase of chub mackerel to 40% caused a decrease in appreciation, recorded through ranking, "best" positioning and rating (table 3a). A lower number of citations were also recorded, in particular for "taste" (table 3b). Results suggested that formulation based on 70% tuna and 30% chub mackerel better combined both nutritional value and acceptance.

Table 3: (a) Products ranking: different tuna-chub mackerel percentages

Tuna percentage	Average Ranking (3:best; 1:worst)	Best (%)	Average Rating (1-9)
Tuna 100%	2.3	38	6.2
Tuna 70% + CM 30%	2.3	38	6.2
Tuna 60% + CM 40%	1.9	24	5.7
p	*	*	*

*indicate significant differences among preparations (p ≤ 0.05). CM: chub mackerel

Table 3: (b) Attributes driving the preferences

Tuna percentage	Attributes driving preference (number of citations)				
	Appearance	Odor	Taste	Juiciness	Tenderness
Tuna 100%	0	3	11	1	2
Tuna 70% + CM 30%	0	1	13	2	5
Tuna 60% + CM 40%	0	3	5	0	2
Total	0	7	29	3	9

For the subsequent steps, semi-dried vegetables based on tomatoes, artichokes or eggplants were taken into account for sausages enrichment. In fact, the recommended amount of dietary fibers is about 25 g/day, mainly guaranteed from vegetables, fruit and legumes consumption. Different mechanical and metabolic effects on the gastrointestinal tract can be made by the several classes of fibers available in a mixed meal. Especially in the elderly, an increase in their consumption is fundamental in the treatment of cardiovascular disease[28] and in a wide range of disorders such as constipation, diabetes mellitus, dyslipidemia and obesity[29]. The results of the third products ranking were reported in table 4a. During this test, the best composition above selected (70% tuna and 30% chub mackerel) was used to compare hedonic judgments. As can be inferred from the table 4a, the addition of tomatoes and artichokes improved acceptance, as compared to eggplants. Tomato was first in ranking average, "best" position and average rating, but means were non significantly different from artichokes. Taste was once more the most cited attribute, without differences among products, while spicy was consistently indicated only when tomato

was present (table 4b). Assessors were request to indicate if they recognized vegetable components. Tomato was recognized by 22% of participants, artichoke by 16%, while none identified eggplant. As vegetable addition, tomatoes and artichokes were preferred over eggplant. Some authors do not recommend ranking test for elderly[2], but this type of test, conducted on three samples (to rank best, medium, worse) was easily understood and executed by the assessors, with consistent results in three successive sessions (*a, b, c*). Elder involved in the research demonstrated to be able to handle a 1-9 evaluation scale, providing significant differences to support hedonic judgment. On the other hand, despite a careful choice of attributes, representative of distinct perceptions: visual (appearance), olfactive (smell), gustative (taste), rheological (juiciness), mechanical (tenderness), no clear responses were yielded. In facts, "taste" (Italian: sapore) was

Table 4: (a) Products ranking: addition of tomato, eggplant or artichoke

Vegetable	Average Ranking (3:best; 1:worst)	Best (%)	Average Rating(1-9)
Tomato	2.4	47	6.8
Artichoke	1.7	34	5.9
Eggplant	1.1	19	5.3
p	*	*	*

*indicate significant differences among preparations (p ≤0.05).

Table 4: (b) Attributes driving the preferences

Vegetable	Attributes driving preference (number of citations)				
	Odor	Taste	Spicy	Salt	Tenderness
Tomato	4	15	10	5	4
Artichoke	3	15	3	3	4
Eggplant	7	14	1	3	2
Total	14	44	14	11	10

Table 5: (a) Tetrad test: selected fish-sausage composition with or without potato

Vegetable	Pairs	
Artichoke base	Correct	40
	Incorrect	13
p		*
Tomato base	Correct	32
	Incorrect	21
p		*

*indicate significant differences among preparations (p ≤0.05).

Table 5: (b) Tetrad test: Percentage of choice and average rating

Composition	Best (%)	Average Rating (1-9)
Artichoke	55	6.6
Artichoke + potato	45	6.3
p	n.s.	n.s.
Tomato	56	6.2
Tomato + Potato	44	6.5
p	n.s.	n.s.

Average rating on a nine-point scale. Non significative data = n.s.

consistently the most used term, probably because of its semantic hedonic value (tasty, good taste), was used to emphasize hedonic preferences. When specific sensory traits were proposed to evaluate vegetable additions, "spicy" was properly associated to sausages containing tomatoes, despite the lack in recognizing the ingredient. This suggests the attention of assessors in performing test.

Results of tetrad test
The appropriate intake of proteins and lipids are satisfied by the use of fish and olive oil in the ready meal formulation. In fact, lipids should cover the 25-30% of daily caloric intake. The main amount should be composed by monounsaturated fatty acids and not more than 7-8% of saturated and polyunsaturated fatty acids. Whereby, should be preferably consumed olive oil and fish. The fats from fish (omega-3 fatty acids) held various healthy functions and are useful in the reduction of lipids level in blood (cholesterol and triglycerides). Furthermore, inside the elderly diet is necessary to pay great attention to the quality of the introduced fat. The consumption of monounsaturated fatty acids (MUFA) in vegetable oil form (particularly olive oil) must be preferred to fat from animal source, due to the protective and preventive effects on chronic and degenerative diseases[30]. Carbohydrates are the main source of energy that body makes available through the transformation into glucose. In the elderly subject the carbohydrates intake is approximately 60% of total calories introduced with the diet. In fact, an appropriate amount of carbohydrates is essential to allow an optimum utilization of all nutrients, particularly proteins. Thus, a combination of carbohydrates, proteins and small amount of fats should always be included in every meal. Moreover, inside a proper feeding must being favored foods obtained from whole-grain rich in complex carbohydrates (bread and pasta) or starchy foods (potatoes, legumes and some vegetables), instead the consumption of carbohydrates in the simple forms (sugar, honey, jam)[31].

Since tomatoes and artichokes resulted the most appreciated vegetable ingredients, both of them were tested with the addition of potatoes. Table 5a and 5b reports the selected fish-sausage composition with or without this new tested ingredient. Tetrad tests investigated the ability of the panel to recognize potato addition in fish-sausages. Potato enriched sausages were correctly recognized, either when tested on tomatoes or artichokes-based sausages (table 5a). Hedonic judgement and rating data were taken into account only for participants showing the ability to perform the tetrad test, by a correct identification of pairs. All compositions had positive evaluations (> 6) while preference was not significant (table 5b). Tetrad test has been demonstrated to be more suitable than triangle test to identify differences between two products[32,33]. Despite the task of evaluating four samples, indicated as vary demanding for older people[2], the test was chosen for its straight aim, based on the thurstonian hypothesis[33]. The task "make pairs of identical samples: 2 best; 2 worse" was gladly executed, yielding positive discrimination results. This was an important indication of assessors' sensory and cognitive ability, which would not have been recorded by a simple hedonic test, since products resulted equivalent in terms of appreciation, as expressed either through paired comparison or rating.

New healthy balanced ready-to-cook meals were produced from the combination of minced fish with extra virgin olive oil, semi-dried vegetables and potatoes. The development of a high nutritional food was pursued by the creation of original products characterized by equivalent nutritional value that were evaluated by elder people. Results of this study suggested that to design successful "novel foods" for the third age, relevant importance has the direct involvement of old population, to help understanding the challenging issue of food changes imposed by age-health constraints[34]. Recent reviews indicate how the studies on sensory evaluation needs and wants of senior consumers, despite the growing importance of the issue, are limited[6]. This study applied discrimination, ranking and descriptive tests with older people to yield their hedonic judgment. The acceptance scores of senior assessors showed that sequential tests successfully supported the development of 4 products integrating functional properties with eating pleasure. This study, focusing on age related sensory perception, demonstrated how elderly are able to perform not only relatively simple paired comparisons, but more demanding ranking tests. The satisfactory execution of tetrad test suggests the thurstonian approach to be helpful to validate preference tests involving aged people. We have succeeded in designing well-accepted tests by the respondents and easy enough to administrate. Interview to third- and fourth-age persons requires

a special care to avoid refusal and/or anxiety. Seniors are generally unfamiliar with tests, afraid to be under examination or to be cheated. Sequential test protocol was planned in steps, starting from a relatively simple pair comparison, to a more demanding tetrad test. This approach can be used to investigate different food-health related issues, while results will be useful to create nutritionally suited food. The products created in this research will be proposed to elderly consumers to confirm the encouraging hedonic results recorded and test health-nutritional effects of these fish-based functional food.

Conflict of interest
All authors disclose any conflict of interest including any financial, personal or other relationships with other people or organizations that can influence their work.

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