

Molecular caviar” of hydrolyzed collagen from tilapia skin: marketing and sensory perception

Abstract

Development of new commercialized products and new recognized products that are increasingly innovative and promising. Among the ingredients that suit the characteristics, there is the hydrolyzed collagen of Nile tilapia (*Oreochromis niloticus*), extracted from the skin of some promissory tilapia to be discarded, as an alternative due to its nutritional and technological characteristics. Considering the importance of innovation in the food market and the use of healthy and sustainable ingredients for consumers, the marketing and sensory perception of a “molecular caviar” developed with the ingredient hydrolyzed collagen from tilapia skin was evaluated. The new product (molecular caviar) was compared with caviar (from sturgeon), via photographic records and questions about its sensory and marketing aspects, in a questionnaire made available on the Google Forms online platform, between October and November 2021 (pandemic period of SARS-COV 19). After analyzing the data, it was observed that the molecular caviar of hydrolyzed collagen from tilapia skin showed a high level of acceptability and purchase intent. In conclusion, molecular caviar appears as a possibility for the use and consumption of hydrolyzed collagen from tilapia skin.

Keywords: molecular caviar, hydrolyzed collagen, tilapia skin, sustainability, innovation

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Introduction

The creation and development of new edible products and the ability to innovate are vital and competitive tools for anyone working in the food industry. These items are important requirements to attract consumers and remain in the market subject to variations, such as: technology, internationalization, exponential and constant launch of new types of food. This industrial segment has increasingly invested in the launch of alternative, healthy and sustainable products. A very promising alternative is the reuse of waste from the fish filleting industry, especially the skin of Nile tilapia (*Oreochromis niloticus*).

Tilapia skin is rich in collagen and has a specific composition of amino acids with a high content of glycine, proline and hydroxyproline.¹ Collagen can promote metabolic processes, reducing intestinal inflammation, aiding in skin regeneration, wound healing, preventing high blood pressure, gastroesophageal reflux, and relieving symptoms of sacropenia, osteoarthritis, osteoporosis, and arteriosclerosis.^{2,3} In addition, hydrolyzed fish collagen is an osteoinductive, environmentally sustainable and cost-effective biomaterial, and has shown beneficial effects in increasing human collagen synthesis and attenuating signs of aging, greatly improving the appearance of the skin.⁴ The hydrolyzed collagen from tilapia skin has a fibrillar nature (typical of type I collagen) and polymeric that can be used in several applications, such as the generation of biomaterials and the manufacture of new foods.⁵ The most important characteristic of hydrolyzed collagen is its amino acid composition, mainly glycine and proline, making it also considered an ingredient that contributes to cartilage stability and regeneration.⁶ Considering the importance of innovation in the food market, the objective of this work was to evaluate the market and sensory perception of molecular caviar developed with hydrolyzed collagen from tilapia skin.

Materials and methods

The study is classified as experimental, due to the development of the “molecular caviar” of hydrolyzed collagen from tilapia skin (MC) and application of an online questionnaire to find out the opinion of the volunteer respondents about the evaluated product.

Study object

The “Molecular Caviar” (MC) subjected to analysis of the perception of likely consumers was developed at the Federal University of Piauí (UFPI), through the direct spherification technique, using hydrolyzed collagen from Nile tilapia skin, sodium alginate and calcium chloride.⁷ Then, the MC was transferred, with the aid of a stainless steel spoon, to a glass container with a lid, previously sterilized and with a capacity of 50 mL. The prepared product was kept under refrigeration (7.0 to 10.0 °C).

Study period and data collection method

The study was applied to determine the marketing and sensory perception of the MC, by likely consumers using a questionnaire made available on the Google Forms online platform between October and November 2021, which was released by WhatsApp. The form was intended for people over 18 years of age, as described in the Free and Informed Consent Term (ICF), approved by the Ethics and Human Research Committee (CEP) of the Federal University of Piauí (UFPI) under protocol number 32106720.7.0000.5214 and opinion number 4.218.790. In the collection instrument itself, before starting their participation, each participant read the informed consent and confirmed their knowledge of the research terms, indicating that they agreed to participate.

Data collection instrument

The questionnaire was designed with 19 objective multiple-choice questions, comprising three axes: I) Consumer profile; II) Habits and consumption behavior of caviar and III) Acceptance and purchase intention of molecular caviar (Figure 1).

Consumer profile
1. What is your age group? 2. What is your gender? 3. Are you color blind? 4. What is your education? 5. What is your income? 6. Do you know caviar? 7. Did you know that to obtain caviar it is necessary to remove the eggs of a female that is still alive?
Caviar consumption habits and behaviors
8. Have you ever had caviar or caviar substitutes? 8.1 If NO, why didn't you consume it? 8.2 If YES, do you know the origin of the eggs you ate? 9. In what occasion have you eaten fish eggs? 10. How often do you eat caviar or substitute? 11. Do you know the origin of the eggs you ate? 12. What sensory attribute do you consider important in caviar? 13. What sensory attribute(s) should a caviar-like product retain in relation to the original (sturgeon caviar)?
Purchase intent and acceptance of "molecular caviar"
14. Would you buy a caviar substitute product at a lower price than the original and formulated with hydrolyzed collagen from Nile tilapia skin? 14.1 YES 14.2 NO 15. What type of packaging is most attractive for marketing a caviar substitute product? 16. How would you like this product to be preserved for sale? 17. Rate how optimal sample A is relative to sample B for color, size, and shape attributes. (Consider: 1 = very weak; 2 = weak; 3 = ideal; 4 = strong; 5 = very strong) 18. For each attribute listed, how much did you like PRODUCT A? (Consider: 1=dislike very much; 2=dislike very much; 3=dislike moderately; 4=dislike slightly; 5=neither like nor dislike; 6=like slightly; 7=like moderately; 8=like very much; 9=like very much) 19. What is your purchase intention for PRODUCT A? (Consider: 1=certainly would not buy; 2=probably would not buy; 3=I doubt whether to buy; 4=probably would buy; 5=certainly would buy).

Figure 1 Survey applied to identify the consumer profile, caviar consumption habits and behavior and the acceptance and purchase intention of molecular caviar.

To evaluate the visual perception of the interviewees regarding aspects of color, shape and size, CMT images were compared with photos of sturgeon caviar (Figure 2). For product acceptance analysis, a structured 9-point hedonic scale was used, ranging between the hedonic terms "extremely disliked (1)" and "extremely liked (9)" and for purchase intention analysis, the structured hedonic scale of 5 points, ranging between hedonic terms "would certainly not buy (1) and would certainly buy (5)".^{8,9}

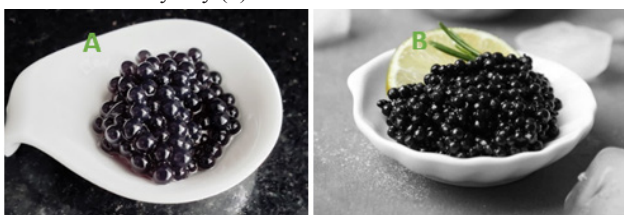


Figure 2 A Molecular caviar and **B** Caviar.

Data analysis

The data resulting from the survey responses were compiled in an electronic spreadsheet to carry out the analyses, crossings and correlations and, later, cluster and discriminant analysis, allowing the identification of the different clusters of consumer's perception.

Results and discussion

Study object

Caparoso¹⁰ emphasizes the importance of applying molecular gastronomy, such as direct spherification, in creating new products

and transforming conventional foods into foods that offer a low-cost sensory experience for consumers who value the harmonization of dishes and high gastronomy. The result shown in Figure 3, demonstrates that the MC obtained through the direct spherification technique presented a spherical shape, black color, shiny and gelatinous appearance.



Figure 3 Physical aspect of the MC.

The encapsulation of hydrolyzed collagen from tilapia skin using sodium alginate occurs satisfactorily, demonstrating its biocompatibility and ability to form a hydrogel through ionic cross-links with divalent cations, such as calcium ions. According to Bennacef et al.¹¹ gelation occurs in solution when calcium ions replace sodium to cross-link two alginate chains and form a network with two antiparallel polyurethane chains linked to Ca²⁺ binding blocks.

Consumer profile

Understanding the consumer's profile is important to create an opportunity for the launch and success of new food products. Because they are largely responsible for the sustainability of the market and also those who drive it. When new product development teams understand the consumer profile, they focus their development efforts to meet the needs of this particular audience.¹² The consumer profile in this study was identified through the survey, answered anonymously and voluntarily by 185 people. Most participants were between 30 and 40 years old (34.1%), were women (72.24%), had specialization (34.6%) and had a family income between six to ten minimum wages (28.6%). Still out of the total number of respondents, 177 (95.7%) confirmed they were not colorblind and 128 (69.2%) knew caviar, but 62.7% did not know that it was extracted from the female sturgeon fish that was still alive (Table 1).

Table 1 Profile of interviewees regarding socioeconomic aspects and way of obtaining caviar

Variables	Frequency (n)	Percentage (%)
Age Group (years)		
18 a 30	42	22,7
31 a 40	63	34,1
41 a 50	53	28,6
51 a 60	18	9,7
> 60	9	4,9
Genre		
Male	48	25,9
Feminine	134	72,4
I prefer not to inform	3	1,6

Table Continued...

Variables	Frequency (n)	Percentage (%)
Education		
Incomplete elementary school	1	0,5
Complete primary education	1	0,5
Incomplete high school	1	0,5
Complete high school	9	4,9
Incomplete higher	21	11,3
Graduated	39	21,1
Specialization	64	34,6
Master's degree	23	12,4
Doctorate degree	26	14,1
Income (salary)		
<1	8	4,3
1 a 2	29	15,7
>2	50	27
6 a 10	53	28,6
>10	45	24,3
Color blind		
Yes	177	95,7
No	8	4,3
Know Caviar		
Yes	128	69,2
No	57	30,8
Do you know that caviar is obtained from female sturgeon still alive?		
Yes	69	37,3%
No	116	62,7%

According to Plasek et al.¹³ several factors can influence the perception, consumption and acceptance of food, including sociodemographic factors such as age, sex and income. The results presented in Table 1 demonstrate that most consumers in this study are young adults, aged between 30 and 40 years, that is, an audience that is more likely to consume foods based on physiological health claims. In addition, it is worth noting that most consumers already know caviar (69.8%), an important factor, because according to Pinto et al.¹⁴ food familiarity presents an advantage for unfamiliar products when they can be visually linked to well-accepted or preferred foods and past tasting experiences. Additionally, health concerns moderate the integration of a new food into a regular diet and can help make it acceptable.

Habits and behavior of caviar consumption

The importance of food choices has been highlighted in the media and many academic and market studies have sought to understand how consumer habits and behavior influence product selection. Different factors have been highlighted, mainly the nutritional point of view, forms of food and sustainability.¹⁵ Furthermore, Tuorila et al.¹⁶ suggest that an appearance of a new food when similar to a familiar product can increase acceptance by consumers. Thus, some habits and behaviors of caviar consumers were investigated and presented in Table 2.

Table 2 Identification of consumer habits and behavior regarding caviar consumption

Variables	Frequency (n)	Percentage (%)
Have you ever had caviar or substitute?		
No	123	66,5
Yes	62	33,5
When did you eat fish eggs?		
I have never eaten	93	50,6
Events	39	21,1
Japanese restaurant	28	15
Others	25	13,3
How often do you eat caviar or substitute?		
I have never eaten	100	54,1
Once a year	67	36,2
Others	18	9,7
Do you know the origin of the eggs?		
No	92	50
Salmon	39	21
Sturgeon	36	19,4
Others	18	9,6
Important sensory attribute in caviar		
Flavor	93	50,6
Color	40	21,5
Texture	30	16,2
Consistency	11	5,9
Size	11	5,8
Important sensory attribute in a caviar substitute		
Flavor	102	55,5
Color	34	18,6
Texture	18	10,0
Consistency	16	8,4
Size	15	7,5

The results show that, among the interviewees, only 33.5% have already eaten caviar or its substitute at festive events (21.1%) or Japanese restaurants (15%) and the frequency of this consumption was, for the most part, a once a year (36.2%). According to Costa et al.¹⁷ the high commercial value found in most commercialization channels for fish and its derivatives, along with other factors such as ease of preparation, food taboos and regions of low productivity, make it difficult to increase consumption by the population. Lopes et al.¹⁸ studying the profile of fish consumption by the Brazilian population, observed that the income range of the participants was above six minimum wages, that is, results similar to those of this study. However, he noted that even people with greater financial power, who can opt for more expensive products, choose to consume other types of cheaper protein, which may justify the low frequency of fish and derivatives, including caviar.

As for the origin of the eggs they ingested, 50% of the participants could not answer what type of fish it was. Only 21% said they had eaten salmon roe and 19.4% had eaten sturgeon. Beluga or “black” caviar is mainly obtained from sturgeon from the Caspian Sea in Iran. It is the second most expensive caviar in the world and the most common, even though it is relatively rare. It can vary in color from pale silver-grey to dark gray. Its flavor is salty, balanced and buttery. However, this sensory characteristic is easily deteriorated by lipid oxidation, protein degradation and microbial growth, which affect the acceptability of the product and bring great losses in production.¹⁹ In addition, the overexploitation of sturgeons for caviar processing has drastically reduced the population of sturgeons that have a reproductive cycle of 7 to 10 years. Therefore, there is a demand for food alternatives similar to caviar, such as molecular caviar and reconstituted caviar.²⁰ Regarding the sensory attributes considered important in a caviar, the interviewees indicated as the most relevant flavor (50.6%), followed by color (21.5%), texture (16.2%), consistency (5, 9%) and size (5.8%). And the most relevant for a caviar substitute were: the taste (55.6%), the color (18.6%), the smell (8.4%) and the size (7.5%) (Table 2). Binsi et al.²¹ for example, converted freeze-dried carp roe dough into caviar substitute by reconstitution with sodium alginate, and obtained, in one of their tests, a product with a soft and spongy texture. Tsai et al.²² spherified functional compounds from radish by-products and obtained a plant-based caviar substitute capable of releasing the phenolic compounds, encapsulated in the spheres, in the stomach and small intestine. It is noticed that there are different possibilities, objectives and functionality in the elaboration of caviar substitutes. And that the technique used is spherification, derived from molecular gastronomy, to obtain resistant spheres similar to caviar.

Purchase intention and acceptance of “molecular caviar”

The growing demand for healthy, practical and sustainable products by consumers leads to the need for the market to innovate and create products, however, it needs to meet consumer expectations and keep up with the latest trends. In this way, respondents were presented with images of sturgeon caviar and molecular caviar (Figure 4) and asked about appearance, acceptance and purchase intent and presentation.

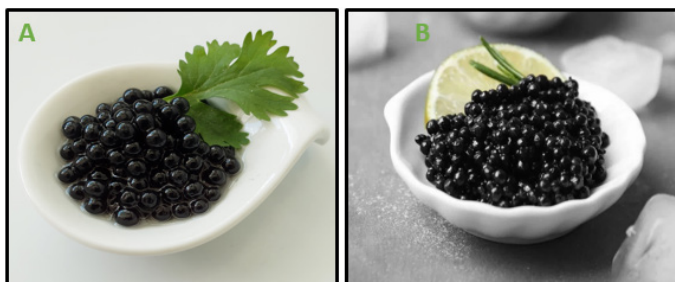


Figure 4 A “Molecular caviar” of hydrolyzed collagen from tilapia skin and **B** Sturgeon caviar.

In the evaluation of the appearance of the new product, the interviewees evaluated the aspects of color, shape and size (Table 3). Well, according to Caballero et al.²³ the first sensory perception of the consumer in relation to a product is linked to its geometry, dimensions, shape, color and brightness.

Regarding the color of the new product, 61 respondents (33%) rated it as “strong” compared to the original caviar, 57 people (30.8%) considered it “very strong” and 46 (24.8%) “ideal”, while none of the interviewees considered the color to be weak or very weak when compared to sturgeon caviar. The intense color of MC is due to the

addition of an artificial black dye that is more stable than the melanin naturally present in sturgeon eggs. Panzella et al.²⁴ states that melanin, present in fish eggs, is the result of a natural biological process to protect the development of the embryo and that, therefore, its color is variable.

Table 3 Evaluation of the appearance of molecular caviar in terms of color, shape and size when compared to sturgeon caviar

Variables	Frequency (n)	Percentage (%)
Color		
Very strong	57	30,8
Strong	61	33
Ideal	46	24,8
Weak	15	8
Very weak	6	3,4
Format		
Very strong	61	33
Strong	56	30,3
Ideal	50	27
Weak	15	8,1
Very weak	3	1,6
Size		
Very strong	48	26
Strong	67	36,2
Ideal	49	26,5
Weak	14	7,6
Very Weak	7	3,7

The molecular caviar shape was considered “very strong” by 61 (33%) of the participants and “ideal” by 27% of them, while the size was considered “strong” by 67 (36%) of the participants and “ideal” by another 49 (26.5%). The perception of greater standardization in the format of the MC, in relation to caviar, is due to the use of a drip plate with 96 standardized holes of 0.35 mm, which allowed the formation of more uniform spheres than those of the original product.

To better understand the acceptance of the MC, respondents evaluated the attributes of color, shape and size using the nine-point structured hedonic scale (Table 4). Acceptance is an expression of the highest degree of taste for a product, on a hedonic scale, becoming an important tool to assess the preference and/or acceptance of products and access, in a very direct way, the consumer’s opinion to a already established product or the potential of a new product.²⁵

When presented to the MC, most participants answered that they “liked a lot” the color (26%), the format (26.5%) and the size (26.5%) of the evaluated product, with an Acceptability Index (AI) of 77.7% for all attributes evaluated, a result similar to that found by Atayde et al.²⁶ for fishburger (72.85%). AI with market potential has been considered $\geq 70\%$ ^{27,28} which demonstrates the potential of MC.

When it was asked about the presentation of the product and purchase intention, most respondents stated that they were interested in purchasing a caviar substitute product (MC) at a lower price than the original, 81.1% of the participants stated that they were interested in acquisition of the new product and indicated a preference for glass

packaging for marketing the product (76.2%) and under refrigeration (70.2%) (Table 5).

Table 4 Sensory acceptance of “molecular caviar” in terms of color, shape and size parameters

Variables	Frequency (n)	Percentage (%)
Color		
I liked it very much	43	23,2
I really liked	48	26
I liked it moderately	25	13,5
I liked it slightly	13	7
I didn't like or dislike	9	4,9
I slightly disliked	22	11,9
I moderately disliked	8	4,3
I disliked a lot	8	4,3
I disliked it very much	9	4,9
Format		
I liked it very much	43	23,3
I really liked	49	26,5
I liked it moderately	23	12,4
I liked it slightly	13	7
I didn't like or dislike	10	5,4
I slightly disliked	21	11,4
I moderately disliked	11	5,9
I disliked a lot	10	5,4
I disliked it very much	5	2,7
Size		
I liked it very much	40	21,6
I really liked	49	26,5
I liked it moderately	24	13
I liked it slightly	13	7
I didn't like or dislike	11	5,9
I slightly disliked	24	13
I moderately disliked	12	6,5
I disliked a lot	5	2,7
I disliked it very much	7	3,8

Table 5 Perception of respondents regarding the purchase and presentation of a caviar substitute

Variables	Frequency (n)	Percentage (%)
I would buy a lower-priced caviar substitute made with hydrolyzed collagen from Nile tilapia skin		
Yes	150	81,1
No	35	18,9

Table Continued...

Variables	Frequency (n)	Percentage (%)
More attractive packaging for caviar substitute marketing		
Glass	141	76,2
Plastic	17	9,2
Metal	15	8,1
Others	12	6,5
Preference of conservation method for sale		
Refrigerated	130	70,2
Room temperature	31	16,8
Frozen	24	13

The main role of food packaging is the adequate protection of food from external influences and damage. However, an additional function is product representation prior to purchase, so material selection must be carefully determined. Four main groups of packaging materials are used for direct food contact: glass, metal, paper/cardboard (wood included) and a wide variety of plastics. In this study, respondents consider the commercialization of MC in glass packaging more attractive (76.2%), which corroborates the results found by Otto et al.²⁹ where 60% of participants prefer glass as food packaging. Additionally, he notes that most consumers consider plastic to be a low-quality product that is associated with negative perceptions and feelings. In a German study, 50% of participants tried to avoid plastic packaging and 62% of Swedish consumers consider plastic to have the greatest negative environmental impact, followed by metal with 30%.^{30,31} Considering that 81.1% of respondents showed interest in purchasing a caviar substitute product (MC) (Table 4), purchase intention was also evaluated using a five-point structured hedonic scale, where 24.9% would certainly buy and 38.3% would probably buy the MC (Table 6).^{32,33}

Table 6 Analysis of purchase intent of molecular caviar from hydrolyzed tilapia collagen

Variable	Frequency(n)	Percentage (%)
Buy intention		
I would certainly buy	46	24,9
I would probably buy	71	38,3
I doubt if I would buy	40	21,6
I probably wouldn't buy	14	7,6
I certainly wouldn't buy	14	7,6

A prominent factor for the development and interest of consumers in products similar to caviar is the aspect of sustainability, which aims to preserve the sturgeons so exploited during the 20th century. Overfishing, disruption of migration routes, and damage to spawning grounds caused by hydroelectric dams have left the few individuals subject to hunting that has already placed 16 sturgeon species on the vulnerable to critically endangered list.³⁴⁻³⁶

Sturgeon needs to go through a reproductive cycle of at least 7 to 8 years to meet the requirements of the egg retrieval procedure, and in the case of some species this can take more than 10 years.³⁷ Thus, competition in the international market, high costs of reproduction,

natural disasters, diseases and other risks contribute to the elaboration and consumption of caviar substitutes.

Conclusion

Molecular caviar of hydrolyzed collagen from tilapia skin has a high level of acceptability and purchase intention, with greater interest by female, young adults, with higher education and income. This product has marketing potential and appears as a possibility to increase the consumption of hydrolyzed collagen, encouraging healthier eating habits and a sustainable way of replacing sturgeon caviar.

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None.

Conflicts of 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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