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ORIGINAL ARTICLE

Consumer-consumption characteristics of ready-to-eat *sous vide* food products within the habitual context of the household

Características de consumo de alimentos em sous vide prontos para consumo no contexto habitual do lar

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Abstract

Preparing cooked food by *sous vide* is an alternative for the design of products that permit the consumer to eat quickly and practically, without losing the sensory and nutritional characteristics of foods. This study aimed to determine the sensory properties, the overall liking, and the consumer-consumption characteristics and predispositions regarding ready-to-eat high-nutritional-quality preparations made with locally produced vegetables and cooked by the *sous vide* technique. A vegetable millefeuille and a chicken and vegetable hamburger were prepared for sensory characterization. Questions related to the consumer's consumption characteristics and predisposition to purchase this type of product were incorporated into the survey. Consumers performed the sensory evaluation in their home, within the habitual living ambience where they consumed their usual diet. The results revealed that most consumers accepted both millefeuille (100 %) and chicken and vegetable hamburger (92 %) and also reported a predisposition for purchasing both preparations (87 % and 84 %, respectively). The main characteristics that made the consumption attractive were quality (95%), market availability (89 %), lack of practical cooking skills (87 %), the price (84 %), the shortness of time invested in preparation (78 %), and the consumer's occupation (73 %). These types of preparations constitute an innovative alternative for the design of products of higher nutritional quality, without ignoring the requirements for their consumption.

Keywords: Convenience food; Vacuum cooking; Sensory analysis; Consumer opinion; At-home testing; Likelihood of buying.

Resumo

Preparações processadas pelo método *sous vide* são uma alternativa para o design de produtos que permitem ao consumidor comer de forma rápida e prática, sem perda das características sensoriais e nutricionais dos alimentos. O objetivo deste estudo foi determinar as propriedades sensoriais, a apreciação e as características e predisposições para o consumo de pratos prontos de alta qualidade nutricional, com vegetais produzidos localmente e cozidos

pela técnica *sous vide*. Um folhado de vegetais e um hambúrguer de frango e vegetais foram preparados para a caracterização sensorial. Questões relacionadas aos hábitos do consumidor e à predisposição para compra deste tipo de produto foram incorporadas à pesquisa. Os consumidores realizaram a avaliação sensorial em sua casa, no ambiente habitual em que consumiram suas refeições habituais. Os resultados revelaram que a maioria dos consumidores aceitou o folhado (100 %) e o hambúrguer (92 %), e também relatou uma predisposição para a compra de ambas as preparações (87 % e 84 %, respectivamente). As principais características que atraíram o possível consumidor foram qualidade (95 %), disponibilidade no mercado (89 %), falta de habilidades culinárias (87 %), preço (84 %), escassez de tempo investido na preparação (78 %) e ocupação do consumidor (73 %). Esses tipos de preparações constituem uma alternativa inovadora para o design de produtos de maior qualidade nutricional, sem desconsiderar os requisitos para seu consumo.

Palavras-chave: Alimentos de conveniência; Cozimento a vácuo; Análise sensorial; Opinião do consumidor; Teste em casa; Probabilidade de comprar.

1 Introduction

The contemporary consumer has significantly reduced the time invested in planning daily meals by choosing approaches that enable minimization of the time spent making purchases and preparing food (Contini et al., 2018). Several researchers have agreed that the main reasons for this behavior are associated with the long working hours; the need for adults responsible for the family group to enter the workplace; and the increase in single-person households, which status makes consumers inclined to increase fast-food consumption and go out to dinner more frequently (Daniels et al., 2015).

In addition, the current consumer—part of an ever more fully informed and interested audience concerning health and the health of peers—increasingly demands products or preparations of higher nutritional quality that nevertheless retain their sensory characteristics and ideally would require a minimum processing or reconstitution time (Abalos et al., 2020). Products based on vacuum technologies such as *sous vide* cooking are suitable for the design of this type of preparation since that culinary approach is characterized by low-temperature cooking (lower than 100 °C) for long cooking times, in order to obtain an exact cooking temperature at the core of the product, thus incurring less loss of nutrients and volatile substances than occurs with conventional cooking methods (Hernández, 2010). The food, previously packaged in an airtight and heat-resistant container, is controlled by a digital temperature and time regulation with constant water circulation (Hernández, 2010). This technology allows homogeneous cooking with reduced weight loss, due to the preservation of the original juices in the food (Sesmero Carrasco, 2015).

Within this context, new opportunities present themselves to the gastronomic sector for developing appetizing and healthful products, ready-to-eat, by using *sous vide* technique. Only a few empirical studies, however, have been undertaken on consumer's sensory perception of *sous vide* products, which is a fundamental practice in the development of new products (Ares et al., 2008). The sensory properties of food such as appearance, taste, smell, flavor, and texture are critical features in determining the acceptance of new products (Lavilla & Gayán, 2018).

Sensory analysis is a discipline that includes the identification, evaluation, and interpretation of the properties or attributes of food, as perceived by the senses. The approach involves measurement techniques as fundamental as chemical, physical, and microbiological methods. The sensory analysis offers the advantage that the instruments involved are an integral part of the person making the measurements while enabling a determination of the existence of unpleasant aspects in food such as defects in smell or taste or an undesirable texture. These unfavorable properties undermine the willingness to consume food; although the preparation may otherwise be optimally nutritious, healthy, and attractive (García-Segovia et al., 2012).

Most studies that evaluate the sensory characteristics of a product are developed in a laboratory with sensory panels. Those experiments have the advantage of being carried out under controlled conditions, but

nevertheless, fail to represent the habitual context within which food is consumed. Several authors have agreed that the evaluation of a product in the same context in which the consumers usually prepare and consume that food is more realistic than when the test is performed in the laboratory. Jabs et al. (2007) described the appropriate context as a set of effects produced by different favorable conditions and influences: the particular food or drink consumed; the moment of the day; the place; the social circumstances; the mental processes like emotions and feelings; the activities in which the person is immersed; and individual's physical state. For this reason, what is more informative regarding this issue is to carry out the sensory characterization in the context where the consumer lives and partakes of the usual diet. Thus, the acquisition of additional information on the determinants involved in the decision to incorporate different products into a consumer's diet through such an approach is not only possible, however, it should be more precise (Ares et al., 2008).

Vegetables are increasingly recognized as essential for food and nutrition security. Vegetable production provides a promising economic opportunity for reducing rural poverty and unemployment in developing countries and is a key component of farm diversification strategies. Nowadays, neither the economic nor nutritional power of vegetables is sufficiently achieved. Vegetable consumption must therefore be nurtured through supply-side interventions (Schreinemachers et al., 2018) and the preparation of ready-to-eat meals would be an interesting strategy.

Therefore, this study aimed to survey the sensory characterization, the overall liking, and the consumer-consumption characteristics of ready-to-eat high-nutritional-quality preparations cooked by *sous vide*. For this purpose, two new, ready-to-meal meals were developed and tested.

2 Materials and methods

Two new ready-to-eat preparations cooked by *sous vide* were developed at *Instituto de Ciencia y Tecnología de los Alimentos de Entre Ríos* (ICTAER) (in English Entre Ríos Institute of Food Science and Technology, Argentina) as a part of the funded research project PID-UNER 9071, which aimed at developing ready-to-eat dishes optimized in nutritional profile and cooked via *sous vide* technology. The selected meals were a vegetable millefeuille and a chicken-and-vegetable hamburger, illustrated in Figure 1.

Figure 1. Illustration of the two newly developed ready-to-eat preparations. Preparation 1: vegetable millefeuille. Preparation 2: chicken and vegetable hamburger.

2.1 Sample preparation

The ingredients used in the millefeuille and the hamburger were bought in a local market and in an agroecological fair from the city of Gualeguaychú. Vegetables were selected considering their freshness, firmness and absence of microbial or mechanical damage.

All-vegetable millefeuille was prepared with fresh sweet potato *(Ipomoea batatas* (L.) Lam*)* and criollo zucchini (*Cucurbita pepo* L); dried tomato, cheese, egg, starch, and milk. The vegetables were thoroughly washed with a tap, dried with tissue paper, and cut into slices of about 3 mm in thickness. For the assembly, the ingredients were sequentially overlaid as follows: sweet potato (17 %); cheese (10.5 %); zucchini (25 %); dried tomato (11 %); cheese (10.5 %); and finally sweet potato (17 %). Between each layer, a sauce made with starch, egg, and milk was added (9 %). Once assembled, the samples were vacuum-packed in a vacuum sealer (Vacuum Packing ICC, Barcelona, Spain) in polyamide-polyethylene bags (O_2 permeability, 25 to 30 cm^3/m^2/day water vapor permeability of 5 g/m^2/day) and cooked by *sous vide* in a constant water-circulation bath with temperature and time regulation (RONER COMPACT, ICC, 80060, Spain) for 50 minutes at 80 °C.

Chicken-and-vegetable hamburger's ingredients were ground and mixed in a kitchen processor (ATMA, 8601, Argentina) for 3 minutes in the following proportions: 67 % of deboned chicken drumsticks, 15 % of steamed pumpkin (*Cucurbita moschata* Duchesne), 15 % of steamed carrots (*Daucus carota* L.), 2 % of rice bran, and 1 % of spice-mix (garlic, parsley, oregano, pepper, paprika, ground black pepper, thyme and bay leaf). The hamburgers were made from 80-g portions of the final mixture in stainless-steel molds 9 cm in diameter and 1 cm deep. Each hamburger was seared for 10 seconds on each side on a hot iron skillet (200 °C), vacuum-packed, and *sous vide* cooked for 15 minutes at 75 °C.

After cooking, both preparations were placed in a 0 °C water bath for 5 minutes for rapid cooling. The samples were refrigerated at 3 °C thereafter until distribution to the participant's houses.

2.2 Participants

The participants were recruited by social media using an on-line questionnarie. For recruitment, participants had to be over 18 years old, reside in the city of Gualeguaychú, consume ready-to-eat food at least once a month and intend to participate in the study. The sample size was chosen based on Olsen et al. (2012) who had employed similar qualitative research. The final sample comprised 119 consumers of a total of 178 people who answered the on-line questionnaire—aged between 18 and 75 years of age.

2.3 Questionnaire design and data collection

The two preparations were delivered to consumers' homes, maintaining refrigeration conditions and requesting consumers to keep them in the refrigerator until consumption.

The questionnaire—prepared specifically for this work—consisted of three parts, in which the first one was associated with sociodemographic data, consumption habits and food purchases questions. In the second part, consumers had to evaluate with a 7-point hedonic scale the level of satisfaction with the appearance of the preparations in their packaging, and after serving them on the plate and the attributes of taste, smell, color, texture and overall liking. Finally, the questionnaire included yes-or-no questions and another section of open questions concerning consumer-consumption characteristics—*i. e.*, quality, shortness of preparation time, the consumer's work activities and cooking skill, and the market availability and pricing. Several authors considered these details as the principal determinants of consumption predisposition (Brunner et al., 2010; Daniels et al., 2015; Brunner, 2016; Jackson & Viehoff, 2016). The participants had to state the reasons underlying their response to each of the inquiries on those details.

The form had clear instructions for the reconstitution of the sample, and eye-catching questions in order to motivate the participant to complete the exercise. Between 24 and 48 h later, the completed questionnaires were withdrawn.

The study was approved by the ethics committee of the Faculty of Bromatology, of the National University of Entre Ríos (RESOLUTION "C.D" N ° 017/17).

2.4 Statistical analysis

The data analysis was carried out through the use of the statistical software IBM SPSS Statics 24. In both preparations, Analysis of Variance (ANOVA) was performed to evaluate the differences ($p < 0.05$), between the product received and after serving it on the plate. Multiple regression was used to investigate the influence of the specific sensory attributes (color, taste, texture, smell) and the appearance of the preparation—both at the time of receiving the prepackaged products and after being served and consuming the prepared foods—on the overall liking.

The reasons underlying the details of the product were grouped into categories for a more realistic analysis. This grouping was carried out by three researchers who considered synonymy.

3 Results and discussion

3.1 Participants characterization

The participants were over 18 years old and were invited to participate through social networks. Table 1 lists the socioeconomic information; the routine consumption of a special diet; the consumer's buying habits; and the food-processing circumstance of the participant.

Table 1. Participant's characterization.

Characteristics	Categories	% (n = 119)
Gender	Female	75
	Male	25
Age groups	18-39	71
	40-59	21
	Over 60	8
Marital status	Single	64
	As a couple	29
	Divorced	5
	Widowed	2
Occupation	Studying	36
	Working	46
	Unemployed	15
	Retired	3
Education level	Primary or secondary school	28
	Tertiary or higher	72
Special Diet	Yes	13
	No	87
Purchase food	Does food shopping	56
	Shopping as shared activity	24
	Shopping by another person	20
Preparation of meals	Makes the meals	58
	Meal preparation as shared activity	22
	Meals prepared by another person	20
Purchase of ready-to-eat meals	Yes	83
	No	17

3.2 Sensory acceptability

3.2.1 Sensory attributes

Table 2 summarizes the means and Standard Deviations (SD) of the scores given by consumers when evaluating each of the sensory attributes of the preparations studied.

Table 2. *Sous vide* products sensory descriptive statistics.

Sensory attributes	Vegetable millefeuille	Chicken and vegetable hamburger
	Mean ± SD	Mean ± SD
Taste	6.06 ± 1.16	5.76 ± 1.35
Smell	5.55 ± 1.30	5.69 ± 1.35
Color	5.99 ± 1.03	5.77 ± 1.37
Texture	5.61 ± 1.22	5.57 ± 1.54
Packing appearance	5.34 ± 1.35[a]	5.65 ± 1.35[a]
Dish appearance	5.92 ± 1.08[b]	6.23 ± 1.08[b]

Packing and dish appearance scores with different superscripts are significantly different according to Tukey's test at a confidence level of 95%.

The arithmetic means of the sensory attributes of the samples evaluated of both the vegetable millefeuille and the chicken-and-vegetable hamburger corresponded to the respective categories “I like it slightly” (at 5 points), while only the taste of the millefeullie and the dish appearance of the hamburger received values corresponding to the category “I like it moderately” (at 6 points). The sensory attributes’ liking could be due to the fact that the *sous vide* cooking technique improves the sensory and quality characteristics since it generates minimal losses in weight and nutrients. It contributes to the preservation of volatile compounds and to avoid oxidative deterioration, responsible for undesirable odors and flavors, in addition to increasing tenderness, thus improving texture (Kosewski et al., 2018).

Table 3 demonstrates that the dish appearance of both preparations to be consumed improved the acceptability to the consumer when compared with the products when observed in the package, as indicated by significant differences between the two means ($p < 0.05$). Visual perception was one of the main characteristics that the consumer evaluated when accepting a product. Therefore, it is necessary to determine the initial visual impression of the preparations because—albeit perhaps only psychologically—the appearance can indeed affect the perception of the taste and texture (Olsen et al., 2012). In the present study, the preparations being served on the plate improved the food's acceptability because of the favorable initial visual impression, which finding would make consideration of packaging design necessary for any commercial product (Roascio-Albistur & Gámbaro, 2018).

Table 3. Multiple-regression analysis of the specific sensory attributes affecting the overall liking of the preparations.

Sensory attributes	Vegetable millefeuille		Chicken and vegetable hamburger	
	t	Significance	t	Significance
Taste	2.024	0.045	7.500	0.000
Smell	1.575	0.118	3.512	0.001
Color	–0.450	0.653	0.161	0.872
Texture	4.867	0.000	3.200	0.002
Packing appearance	6.141	0.000	2.124	0.036
Dish appearance	1.638	0.104	–0.914	0.362
R^2	53.3%		75.7%	

$p < 0.05$.

The acceptance of new food products is determined by the conditions related to both the products and the consumers. The product's visual appearance, texture, and taste are fundamental characteristics for establishing favorable consumer sensory and hedonic responses (Santagiuliana et al., 2019).

3.2.2 Overall liking and likelihood of buying

The consumers evaluated both the millefeuille (100 %) and the chicken and vegetable hamburger (92 %) positively—as comprised in the categories "I do not like or dislike it", "I like it slightly", "I like it moderately", and "I like it very much". The multiple-regression results indicated that the overall liking of the products evaluated was highly influenced by taste, texture, and appearance on the plate. Besides, as would be expected, the taste had a significant effect on the overall liking of the food— thus being in accordance with Olsen et al. (2012), Andrés-Bello et al. (2013), and Phan & Chambers IV (2016), whom all recognized those attributes as the main determinants of acceptability by the consumers.

In the case of the millefeuille, the overall liking was highly influenced by the attractiveness of the texture and appearance on the plate. At the same time, the appeal of the taste had a significant effect on the overall estimation. Regarding the chicken and vegetable hamburger, the appropriateness and acceptability of the taste influenced the overall opinion of liking or disliking it highly; while the liking of the smell, texture, and appearance on the plate likewise made a significant contribution (Table 3).

For the sensory evaluation to be carried out within the usual context of routine food consumption, the participants had to eat the preparation accompanied by a garnish or in a sandwich containing the hamburger. The majority of the participants (58%) decided to accompany the millefeuille with mixed salads (lettuce and tomato, tomato and carrot, tomato and onion) and mashed potatoes or white rice.

With the chicken and vegetable hamburger, most consumers (82 %) decided to eat the preparation in a sandwich or accompanied by salads (carrot and egg, tomato and carrot, tomato only, tomato and egg) and white rice or noodles. In this case, the type of garnish or sandwich did not have significant effects on the sensory acceptability of the different attributes or the global acceptability of both preparations (Table 4).

Table 4. Effect of garnish on sensory attributes.

Preparation	Sensory attributes	With garnish	Without garnish
Vegetable millefeullie	Overall liking	6.01 ± 0.80[a]	6.22 ± 0.84[a]
	Taste	6.00 ± 1.16[a]	6.16 ± 1.17[a]
	Smell	5.30 ± 1.30[a]	5.50 ± 1.25[a]
	Color	6.04 ± 0.95[a]	5.92 ± 1.14[a]
	Texture	5.61 ± 1.17[a]	5.60 ± 1.31[a]
Chicken and vegetable hamburger	Overall liking	5.85 ± 1.29[a]	5.95 ± 1.46[a]
	Taste	5.78 ± 1.29[a]	5.71 ± 1.62[a]
	Smell	5.96 ± 1.38[a]	5.67 ± 1.24[a]
	Color	5.76 ± 1.32[a]	5.81 ± 1.60[a]
	Texture	5.51 ± 1.54[a]	5.86 ± 1.56[a]

The results indicated that the majority of the consumers manifested a positive attitude towards the purchase of the millefeuille (87 %) and the chicken and vegetable hamburger (84 %). The intention to purchase these products was also in accordance with the findings of Olsen et al. (2012), who considered overall liking as a driver of the probability of purchase.

3.3 Consumer-consumption characteristics of ready-to-eat meals

Another objective of this investigation aimed to identify the determining considerations leading to the acquisition of *sous vide* ready-to-eat products. Questions related to product quality, price, lack of preparation time, the consumer's work activity and cooking skills, and the market availability were included because sensory characteristics are not the only determinants of purchasing predisposition (Vidal et al., 2013). Table 5 is a synopsis of the results and the examples cited in the text of the reasons for choosing the different preparations for consumption and the accessibility and affordability of those two products for purchasing.

Table 5. Identification of consumer-consumption characteristics.

Characteristics	Categories	Textual examples	% (n = 119)
Quality	Yes	*…are elaborated dishes and must be made with quality ingredient / have good nutritional attributes / nutritional quality, which brings benefits to my diet*	95
	No	*....distrust*	5
Market availability	Yes	*…I like to try innovative and quality products / must be accompanied by information and publicity / should report their benefits and what is about*	89
	No	*…these products are little known, it would not be enough only to insert them in the market*	11
Lack of cooking skills	Yes	*…I like to eat healthy foods even though I don't like to cook them / heating would help me organize, eat varied and healthy / solution to people without culinary skills*	87
	No	*...I make my own food / I have cooking skills*	13
Price	Yes	*…nowadays people take more care in the money they spend / if it is a well-made product, the price you are going to pay should not matter / if the price is too high I would not buy it*	84
	No	*…accessibility is essential*	16
Lack of time	Yes	*…it makes my daily routine easier / they greatly simplify the time it takes to cook / in less than 10 minutes they are ready*	78
	No	*…I have enough time to cook*	22
Occupation	Yes	*…it is a fast-cooking option and mainly healthy / with such extensive and tight schedules between activities / these products facilitate the purchase and food*	73
	No	*...my job does not prevent me from cooking*	27

These types of meals are characterized by purchasing and consumption mainly because of convenience (Phan & Chambers IV, 2016). The present work was designed to characterize less obvious causes and conditions such as those related to product quality and price along with the consumer's work activity, cooking skills, and market availability. The data obtained corresponded to the findings from studies by

Buckley et al. (2007), Brunner et al. (2010), and Osman et al. (2014), where practicality was the key to determining condition along with safety and sensory and nutritional quality.

Quality was the aspect most indicated by the respondents as a determinant of the purchase of convenience food cooked by *sous vide* (95 %). Consumers expressed the essentiality of sensory attributes, raw materials, and nutritional quality when they said that these products "are elaborated dishes and must be made with quality ingredients", and "have good nutritional attributes". The participants (89 %) considered that the consumption of these products would increase if they were available in the market and added "I like to try innovative and quality products", and "[they] must be accompanied by information and publicity". Furthermore, in nontraditional markets, the appropriate packaging design must be included—*i. e.*, one that emphasizes the nutritional benefits, the absence of additives, and the high-nutritional-quality of the products cooked by *sous vide* to favor the daily inclusion of that food in the diet (Roascio-Albistur & Gámbaro, 2018).

Another condition investigated was the lack of cooking skills, in which section it could be noted that 87 % of the participants presented interest in the variety and nutritional quality; stating "I like to eat healthy foods even though I don't like to cook them", that incorporating those products "would allow me to eat something different" and "[eat] healthier foods despite not knowing how to prepare them", and finally that "[such foods] would help me organize, eat a variety of healthy food". As in the Brunner (2016) study, a lack of cooking skills proved to be a determining condition for convenience foods since people with a lower level of cooking skills depended on such processed foods.

Regarding the price, 84% of the participants considered basic accessibility and cost-benefit and price-quality relationships, expressing that "nowadays people spend money to achieve better health", or that "if it is a well-made product, the price you are going to pay should not matter". These results could agree with that expressed by Phan & Chambers IV (2016) in their report, where the participants of their study had chosen ready-to-eat meat products because of the price in addition to their habits, convenience, and search for variety in foods.

Consumers also mentioned the lack of time as a determining characteristic (78 %), and most considered temporal practicality in stating "it makes my daily routine easier", "they greatly simplify the time it takes to cook", and "in less than 10 minutes they are ready". In this regard, 46 % of the participants responded that they had less than 40 minutes to cook them. As expected in this type of product, the time element had a significant positive impact on the purchasing and consumption predisposition according to the results of Osman et al. (2014). In addition to working long hours, eating food alone or not being able to prepare meals increases one's consumption (Dunn et al., 2008).

Finally, the occupation of the consumers was a determining condition for 73 %, who expressed opinions such as "it is a fast cooking option and mainly healthy" and "with such extensive and tight schedules between activities, these products facilitate the purchase and preparation of the food".

4 Conclusions

The home environment constituted an alternative venue for the sensory evaluation of complex preparations of *sous vide* cooked foods. The information obtained enabled the analysis of accurate and innovative findings framed within the everyday context where people commonly consume food. This venue for sensory evaluation enabled the inclusion of a greater number of consumers than the number of participants possible in sensory panels conducted within a laboratory. This type of methodology is promising for use in future research applied to other types of products as well as involving other consumer groups. In addition to practicality, other conditions motivated food-related decisions towards ready-to-eat products such as lack of time in preparation; product quality and price; and the consumer's occupation, cooking skills, and market availability.

These insights garnered from the study reported here could lead to an improvement in the products available in the market. Knowledge of the consumption determinants would contribute to the development of new products in response to food-preparation or safety problems, changing consumer purchasing predispositions, and current marketing demands.

However, the study also had its limitations. Given the exploratory nature of this study, the results should be seen as a first approximation of consumer perceptions of these types of ready-to-eat meals and regarded as an incentive to carry out additional studies such as comparison with sensory analysis in the laboratory.

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