J Food Sci Technol (February 2020) 57(2):617–627
https://doi.org/10.1007/s13197-019-04093-x

ORIGINAL ARTICLE

Sensory and hedonic impact of the replacement of synthetic antioxidant for pink pepper residue extract in chicken burger

Erick Saldaña[1,4] · Juan Serrano-León[1,3] · Miriam Mabel Selani[2] · Carmen J. Contreras-Castillo[1]

Revised: 11 July 2019 / Accepted: 6 September 2019 / Published online: 12 September 2019

Abstract This study aimed to evaluate the sensory and hedonic perceptions of chicken burger manufactured with pink pepper residue extract (PPE) added to the meat and to the chitosan film. Five samples were manufactured: CT: control, without antioxidant; DP and FP: addition of PPE to the meat batter and to the film, respectively; C1 and C2: commercial brands of chicken burgers. Consumers characterized the samples using the overall liking test and Check-all-that-apply questions. The samples showed a medium–high level of acceptance and no significant differences were found between them. DP was the farthest sample from the ideal and FP showed positive results, since its characteristics were like the commercial samples. The direct extract application may lead to a reduction in the liking of chicken burgers, demonstrating that the technology of active films is a viable alternative to the use of natural antioxidant extracts in meat products.

Keywords CATA questions · Pink pepper · Active packaging · Meat product

✉ Carmen J. Contreras-Castillo
ccastill@usp.br

1 Escola Superior de Agricultura "Luiz de Queiroz", Departamento de Agroindústria, Alimentos e Nutrição, Universidade de São Paulo, Av. Pádua Dias, 11, Piracicaba, SP, Brazil

2 Centro de Ciências da Natureza, Universidade Federal de São Carlos, Campus Lagoa do Sino, Rod. Lauri Simões de Barros, Km 12, Buri, SP, Brazil

3 Facultad de Ciencias Químicas, Universidad Central del Ecuador, Quito, Ecuador

4 Facultad de Ingeniería Agroindustrial, Universidad Nacional de Moquegua (UNAM), Moquegua, Perú

Introduction

Because of the growing population concerns about a healthy diet, the consumption of natural products has increased in the last years (Karre et al. 2013). In this context, industry and academia stakeholders are making efforts to either reduce the use of synthetic antioxidants or to replace these substances with natural antioxidants, especially in chicken products, which are highly susceptible to lipid oxidation. The use of different natural antioxidants in meat products has been investigated, including berry extracts (Lorenzo et al. 2017), pink pepper residue extracts (Serrano-León et al. 2018), guava and beetroot residue extracts (Packer et al. 2015), *Rosa canina* L. phenolic compounds (Utrera et al. 2015), avocado phenolics (Rodríguez-Carpena et al. 2011), among other sources.

Scientific evidences support the use of natural antioxidants to decrease the lipid oxidation (Estévez 2017), especially in chicken products that are more susceptible to this deteriorating process. In this regard, Serrano-León et al. (2018) showed the potential of pink pepper extract against lipid oxidation of a restructured chicken product. However, this study did not evaluate the effect of the addition of natural extracts on the sensory quality of the product. It is known that the incorporation of natural antioxidant extracts may modify the sensory quality of meat products (Nuñez De Gonzalez et al. 2008), mainly delaying the occurrence of rancid odor and flavor and avoiding color changes. However, few works have focused on the sensory and hedonic properties of meat-based products manufactured with the addition of antioxidant extracts.

Sensory analysis (SA) is basically -divided in discriminative (Rogers 2017), descriptive (Saldaña et al. 2018a, b, c), and affective (O'Sullivan 2017) tests.

Commonly, descriptive and affective measurements are carried out to identify the drivers of liking (DL). The DL are sensory attributes of food products that modify the consumer liking. In food science and technology, DL attributes have been widely studied (Mielby et al. 2016; Resconi et al. 2016, 2018a, b, c). However, few studies have addressed this issue in meat products.

The sensory profile of a food is obtained by means of descriptive analysis—DA (Saldaña et al. 2015). In this method, a trained sensory panel rates a set of products according to a list of sensory attributes. The training step of the DA provides detailed, reliable, and reproducible results. However, this step is time-consuming and costly. For these reasons, alternative sensory profile methods have emerged in the past 10 years (Ares and Varela 2017).

Recent advances in sensory and consumer research have highlighted that listening to "the voice of the consumer" is increasingly important in the competitive marketplace (Varela and Ares 2018). Therefore, it seems viable to obtain the sensory profile directly from the consumer. A large body of scientific research has focused on the use of CATA questions to perform a consumer sensory profiling of foods (Morell et al. 2015; Valentin et al. 2012; Varela and Ares 2012). This method allows to obtain the sensory profile coupled with the ideal description and OL, representing a potential tool to obtain the DL directly from consumers.

In this context, the aim of this study was to evaluate the sensory perception, the description of the ideal burger and the overall liking of burger manufactured with pink pepper residue extract added both to the meat and to the chitosan film.

Materials and methods

Pink pepper residue and preparation of natural extracts

Pink pepper residue (*Schinus terenbithifolius* Raddi) was supplied by Agrorosa Ltda (São Mateus, ES, Brazil) and was composed of stems, leaves and rejected peppers. The material was ground using a knife mill (IKA A11, Basic, Staufen, Germany), sieved (40-Tyler mesh sieve, ~ 420 µm) and stored at − 18 °C. The extraction of the phenolic compounds was performed according to the described by Serrano-León et al. (2018), using ethanol:water (80:20 v/v). The solution was placed in a water bath (Quimis, Diadema, SP, Brazil) at 95 °C for 25 min, followed by 15 min in an ultrasonic bath USC-1400A (Unique, Indaiatuba, SP, Brazil). Then, the pink pepper extract (PPE) was filtered (qualitative filter paper, thickness: 0.16 mm, filtration speed: 20–25 s, ash content: 0.1%, particle retention: 4–12 µm), centrifuged at 5000 g for 15 min (Eppendorf 5810R) and stored. PPE was previously characterized in terms of content and profile of phenolic compounds, showing 45.01 mg gallic acid/g of pink pepper residue and the phenolic compounds catechin, *p*-coumaric acid, myricetin and epicatechin (Serrano-León et al. 2018, Bergamaschi 2016). It also showed antioxidant activity (in µmol trolox/g pink pepper residue) of 535.74 for the DPPH method, 931.00 for the ABTS method, 158.24 for the ORAC method, as well as an EC50 of 1.24 mg/mL for the radical superoxide (O_2^-) method (Serrano-León et al. 2018).

Preparation of chitosan films

According to our previous studies using response surface methodology (Serrano-León et al. 2018), the volume of PPE equivalent to 90 mg of gallic acid (GA) per kg of meat was defined as the optimal concentration of natural extract for the maintenance of the oxidative stability of chicken burger. Thus, this concentration was used for the preparation of the active films. The preparation of the chitosan (Primex—ChitoClear®, Siglufjordur, Iceland) films was based on glycerol as plasticizer and followed the procedures described by Serrano-León et al. (2018).

Preparation of the chicken burger

Five samples were evaluated in this study, in which 3 of them were manufactured in the Meat Processing Plant of the *Escola Superior de Agricultura "Luiz de Queiroz"—Universidade de São Paulo (ESALQ—USP),* considering 3 independent replicates of each batch. Boneless and skinless chicken thighs and drumsticks (73.46% moisture, 16.87% protein, 7.82% fat, 1.05% ash) were purchased from a slaughterhouse (Rio Claro, SP, Brazil), ground (0.8 cm plate) separately in a grinder (4B22-2; Hobart, Troy, OH, USA) and divided into 3 treatments (about 2.5 kg each one) as follows: CT: without any antioxidant; DP: direct addition of PPE to the meat batter (volume of extract equivalent to 90 mg GAE/kg meat); FP: addition of PPE to the chitosan active film (volume of extract equivalent to 90 mg GAE/kg meat). Sample processing was performed as described by Serrano-León et al. (2018). The other two samples (C1 and C2) corresponded to commercial brands of chicken burgers purchased at the local market (Piracicaba, SP, Brazil).

Sensory methods

All sensory tests were performed after the microbiological analysis of the samples to ensure that they were suitable for human consumption (Brazil 2001). The microbiological analysis was carried out in triplicate, at the laboratory of Higiene e Laticínios of ESALQ—USP. The counts of thermotolerant coliforms, coagulase-positive staphylococci, sulfite-reducing clostridia were within the limits specified by Agência Nacional de Vigilância Sanitária (Brazilian Health Surveillance Agency) and Salmonella was not detected in any of the samples.

This study was approved by the Ethics Committee for Human Research of the—ESALQ-USP (COET/0213, Protocol n° 161). Participants read and signed an informed consent form prior to the sensory tests. The samples were cooked in a hot plate (150 °C) (Edanca, São Bernardo do Campo, SP, Brazil), until achieving the internal temperature of 75 °C. Subsequently, they were cut in 2 cm^3 cubes (Selani et al. 2016), which were placed in a glass container covered with a lid and stored at 40 °C for up to 10 min. All samples were served to the consumers at about 40 °C. Sensory tests were performed in the sensory analysis laboratory of the ESALQ—USP.

Consumers

Eighty-one habitual consumers of chicken burger (26.67 ± 7.45 years old; 45% female) were recruited at ESALQ-USP. The inclusion criterion was based on the consumption of burger once a month. Both in the overall liking and CATA questions, samples were presented monadically to the consumers, following a William's design, using random numbers with 3 digits. Mineral water and unsalted biscuits were provided to rinse the mouth between samples. The number of consumers that participated in this study was higher than 60–80 consumers, as recommended by Ares et al. (2014).

Overall liking and CATA questionnaire

Both sensory evaluations were performed on the same day, since the sensory ballot included the liking test, followed by the CATA question, and the ideal product description (Jaeger and Ares 2014; Ares and Jaeger 2015a). Consumers indicated their overall liking using a 10-point hybrid hedonic scale, anchored at 0 = disliked extremely, 5 = neither liked nor disliked, and 10 = liked extremely (Villanueva et al. 2005). Subsequently, they responded the CATA questions (Ares and Jaeger 2015b), selecting all the attributes that they considered adequate to describe each sample, followed by the description of the ideal burger (Saldaña et al. 2018a). The sensory attributes were preselected by 21 consumers, using the repertory grid method, in which each consumer described the sensory attributes that differentiated each sample. The attributes (Table 1) were randomized between samples and consumers to avoid bias (Ares and Jaeger 2013).

Data analysis

Overall liking

Boxplots were used to show the OL data. Subsequently, an analysis of variance (ANOVA) was used to analyze the liking results, considering sample and consumer as factors. Furthermore, to better understand the consumers' liking, an

Table 1 Contingence table of sensory attributes of the CATA questionnaire for burger samples

Attributes	Samples					
	FP	CM1	CT	DP	CM2	Ideal
Color of chicken burger	64	65	66	65	59	77
Strange odor*	17	9	9	21	14	2
Flavor of chicken burger**	43	43	50	26	34	73
Vinegar flavor***	1	1	1	13	3	2
Rancid flavor	7	10	5	5	11	2
Non-characteristic color of burger	10	8	13	11	9	0
Pepper odor**	4	4	5	12	1	9
Rancid odor	3	4	6	2	5	2
Non-characteristic flavor of burger	28	22	19	29	34	1
Appearance of chicken burger	50	52	49	41	48	72
Odor of chicken burger	45	49	48	35	44	62
Pepper flavor***	17	11	21	44	13	17

CT control; *DP* direct addition of PPE to the meat batter; *FP* addition of PPE to the chitosan film; and *C1* and *C2* commercial chicken burgers

***Significant difference at $p < 0.001$, **Significant difference at $p < 0.01$, *Significant difference at $p < 0.05$. according to the Cochran's Q test

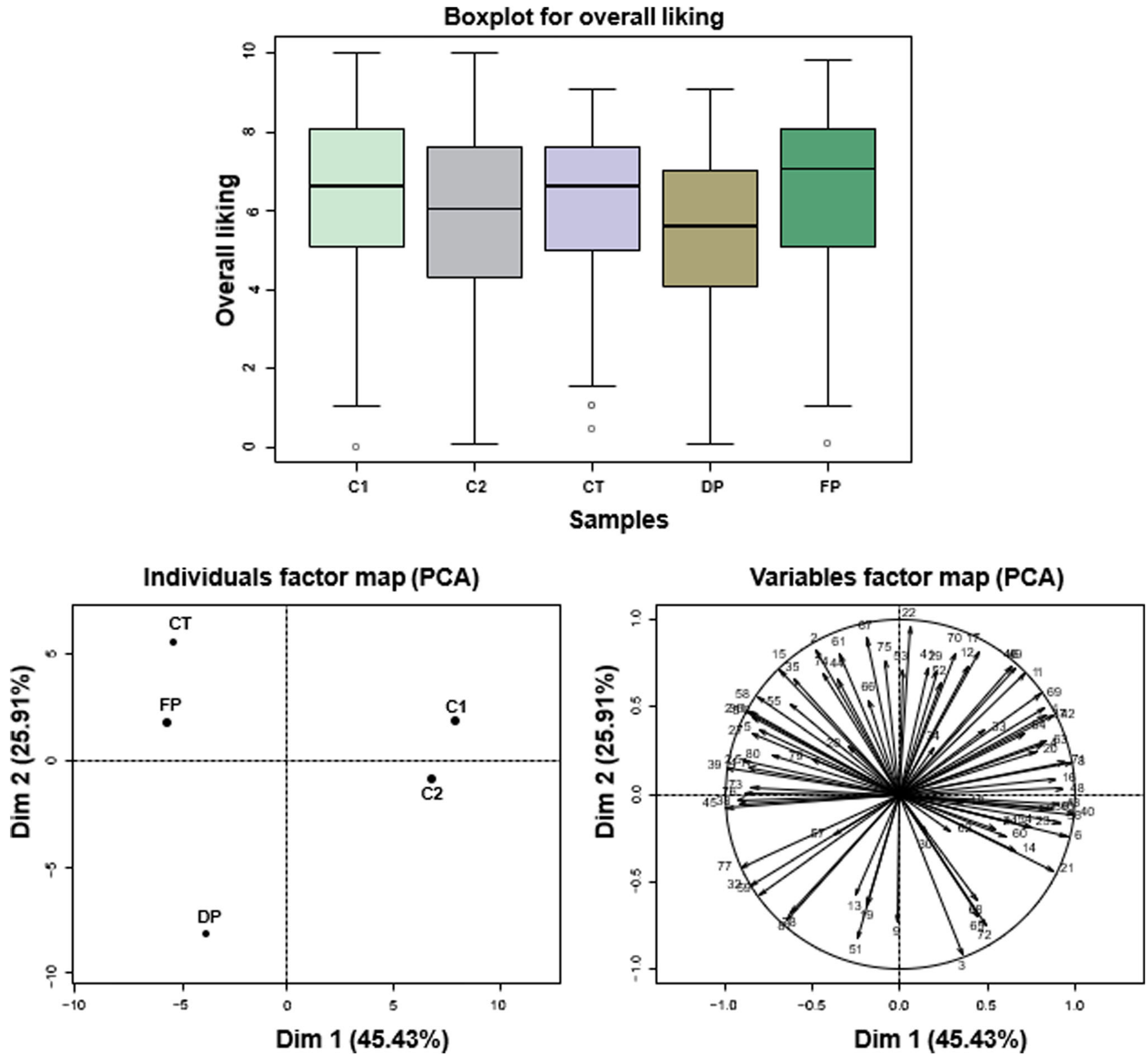


Fig. 1 Overall liking data (boxplot) and internal preference mapping: representation of samples and consumers (variables) on the first two dimensions (Dim 1 × Dim 2). *CT* control; *DP* direct addition of PPE to the meat batter; *FP* addition of PPE to the chitosan film; and *C1* and *C2* commercial chicken burgers

internal preference mapping (*mdpref*) was performed (Saldaña et al. 2018a, b, c). Next, a hierarchical agglomerative cluster analysis was performed to identify the segments of consumers and samples using Euclidian distances and the Ward's linkage criterion were selected.

CATA questions

A contingency table was created to show the sensory attributes that apply to a target and ideal sample. In this table, the Cochran's Q test was used to identify the attributes that are significantly different between samples. Additionally, correspondence analysis (CA) was applied to obtain a sensory map containing not only target and ideal samples as well as sensory attributes. In order to graphically represent the relationship between OL and the sensory attributes, a Principal Coordinates Analysis (PCoA) was carried out based on the Gower's centered similarity matrix (Gower 1966). Finally, a Penalty Analysis (PA) per sample was performed to estimate the attributes that decrease the consumer's liking using Just about right (JAR)-type analysis (Worch 2018). For instance, for a given attribute if both the ideal and the real sample are checked or unchecked, this fact indicates a "JAR" status.

However, if the ideal sample is checked, but not the real sample, it is considered “Too Little” of the attribute. On the other hand, if the ideal sample is unchecked but the real sample is, then it is considered “Too Much” of the attribute. Thus, the mean drop in the OL was calculated by the subtraction of the OL of “JAR” minus “Too Little” or “Too Much”. To check if the mean drops were significant, the ANOVA of liking by JAR groups for each sample was used and compared with “To Much” with “JAR” and “To Little” with “JAR”, at 5% of significance. The statistical analyzes were carried out in the environment R, using SensoMineR and FactoMineR packages.

Results and discussion

Consumers’ liking

Figure 1 shows the boxplot of the consumers’ OL for the five burger samples. According to the ANOVA data, samples presented a similar OL (score 6 cm out of 10 cm). Although the samples did not differ significantly, the DP exhibited a tendency for the lowest score. This result is certainly related to the incorporation of PPE directly to the meat batter, which generated changes in the sensory profile and in the liking of the burgers.

According to the boxplot (Fig. 1), the variability in the overall liking was substantial. For example, the liking scores of the DP sample ranged from 0 to 9. This means that some consumers liked this sample while others did not. This behavior pattern was observed in all samples. For this reason, a deeper analysis was performed through *mdpref*.

Figure 1 also shows the representation of consumers and samples on the first dimensions of the PCA. This representation, also called *mdpref*, clearly showed that the overall liking is segmented. According to the position of the samples in Fig. 1, three groups of consumers can be observed.

As expected, three clusters were identified (Fig. 2). The first cluster was composed of 23 consumers, who preferred the commercial samples (C1 and C2). This means that these consumers have a marked liking for the burgers currently available in the market. The second cluster (n = 27) disliked the DP sample, probably because of the sensory changes caused by the direct addition of the PPE to the meat batter. On the other hand, the data from cluster 3 (n = 31) may be an indicative that the use of PPE in the chitosan film does not affect much the sensory characteristics of the burger, since this cluster preferred both the CT and FP samples. This cluster is a bit more open in its preferences, giving priority to samples made in the laboratory in relation to two selected commercial samples.

Consumer sensory characterization

Table 1 shows the frequency of mention of all the attributes for each sample, including the ideal burger.

According to the Cochran’s Q test (Table 1), there was significant difference between samples in five attributes: “strange odor”, “flavor of chicken burger”, “vinegar flavor”, “pepper odor”, “pepper flavor”. These differences are associated to the addition of PPE to the meat batter and to the active film and, in consequence, to the different degrees of lipid oxidation of the samples. This fact indicates intermediate discrimination by consumers, suggesting that this methodology detected differences in consumers’ perceptions regarding the evaluated chicken burgers. Additionally, when evaluating the ideal chicken burger, consumers described it with following attributes: color of chicken burger, flavor of chicken burger, pepper flavor, appearance of chicken burger, and odor of chicken burger.

Figure 3a shows the Principal Coordinate Analysis of the attributes and the overall liking data allied with the CATA questions data. Attributes that are close to the “overall liking”, such as “flavor of chicken burger” and “odor of chicken burger”, contribute positively to the acceptance. Considering that the ideal burger would present a high consumer acceptance, the data obtained here are consistent, since the attributes that contributed to “overall liking” were the same as those correlated with the “ideal” sample (Fig. 3b). On the other hand, the terms “non-characteristic taste” and “strange odor” are on the opposite side of the “overall liking” and do not contribute to the acceptability of the sample.

The representation of the attributes and samples in the first two dimensions of the CA, performed on the contingence table of the CATA questions is presented in Fig. 3b. The first two dimensions of the analysis were able to explain up to 93% of the experimental data.

Through the representation of the samples in the CA (Fig. 3b), it was possible to clearly differentiate 3 groups, with different sensory characteristics. The first group is formed by the “Ideal” sample, which was correlated with the following attributes: “flavor of chicken burger”, “appearance of chicken burger “, and “odor of chicken burger”. These data are coherent because consumers tend to expect the food product has intrinsic characteristics (“ideal”).

The second group, formed by samples C1, C2, CT, and FP, was correlated with “rancid odor”, “rancid flavor”, “color of chicken burger”, “odor of chicken burger”, and “appearance of chicken burger”. A previous work reported that the CT treatment had significant higher peroxide value and thiobarbituric acid reactive substances than samples DP and FP (Serrano-León et al. 2018), which may explain the rancid odor and flavor. The other attributes can be

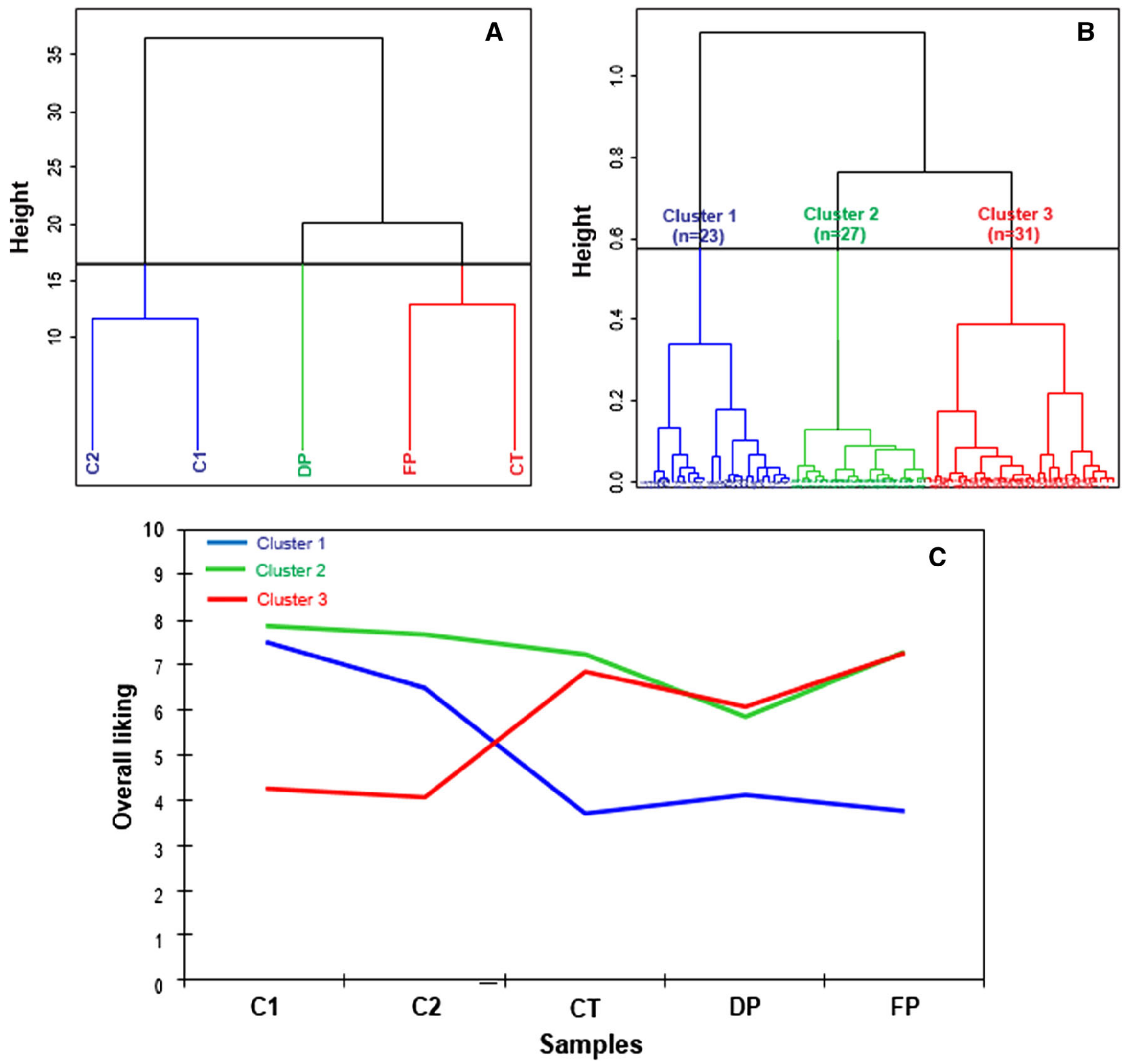


Fig. 2 Cluster analysis: **a** dendrogram of samples, **b** dendrogram of consumers, **c** liking scores by sample and by cluster. *CT* control; *DP* direct addition of PPE to the meat batter; *FP* addition of PPE to the chitosan film; and *C1* and *C2* commercial chicken burgers

considered positive and are probably related to the commercial and the FP samples, which have antioxidants in the formulation, maintaining the sensory quality of the burger.

The third group was composed of the DP sample, which was correlated with "pepper flavor", "vinegar flavor", and "pepper odor". These attributes probably led to the significant decrease in overall liking of the DP burger. Additionally, the DP sample seems to have a more pronounced effect on the sensory characteristics of the product when compared to the FP burger, indicating that the application of antioxidant extracts in chitosan films minimizes the sensory alterations of the product. This result is in-line with those obtained by Selani et al. (2011), who found significant changes on color, odor and flavor of the chicken product manufactured with wine industry residue extracts. Siripatrawan and Noipha (2012) reported an increase in overall liking scores of pork sausage packed with green tea active film compared to the control sample.

Figure 4 shows the mean drop in overall liking as a function of consumers who described each sample differently from the ideal burger. In the penalties plot, the sensory attributes highlighted in bold showed a statistically significant decrease in consumers' liking when the sensory description of the target burgers was different from the ideal burger (Worch 2018). Inconsistencies with the ideal burger were identified as "Too Much" or "Too Little" when the frequency of an attribute was very high or low, respectively. In addition, attributes with a larger font size indicate that they were perceived by more than 20% of consumers (Saldaña et al. 2018a). This pragmatic approach allows the efficient identification of the drivers of liking by sample, which may be used for optimization studies. Overall, 6 attributes significantly decreased the liking of

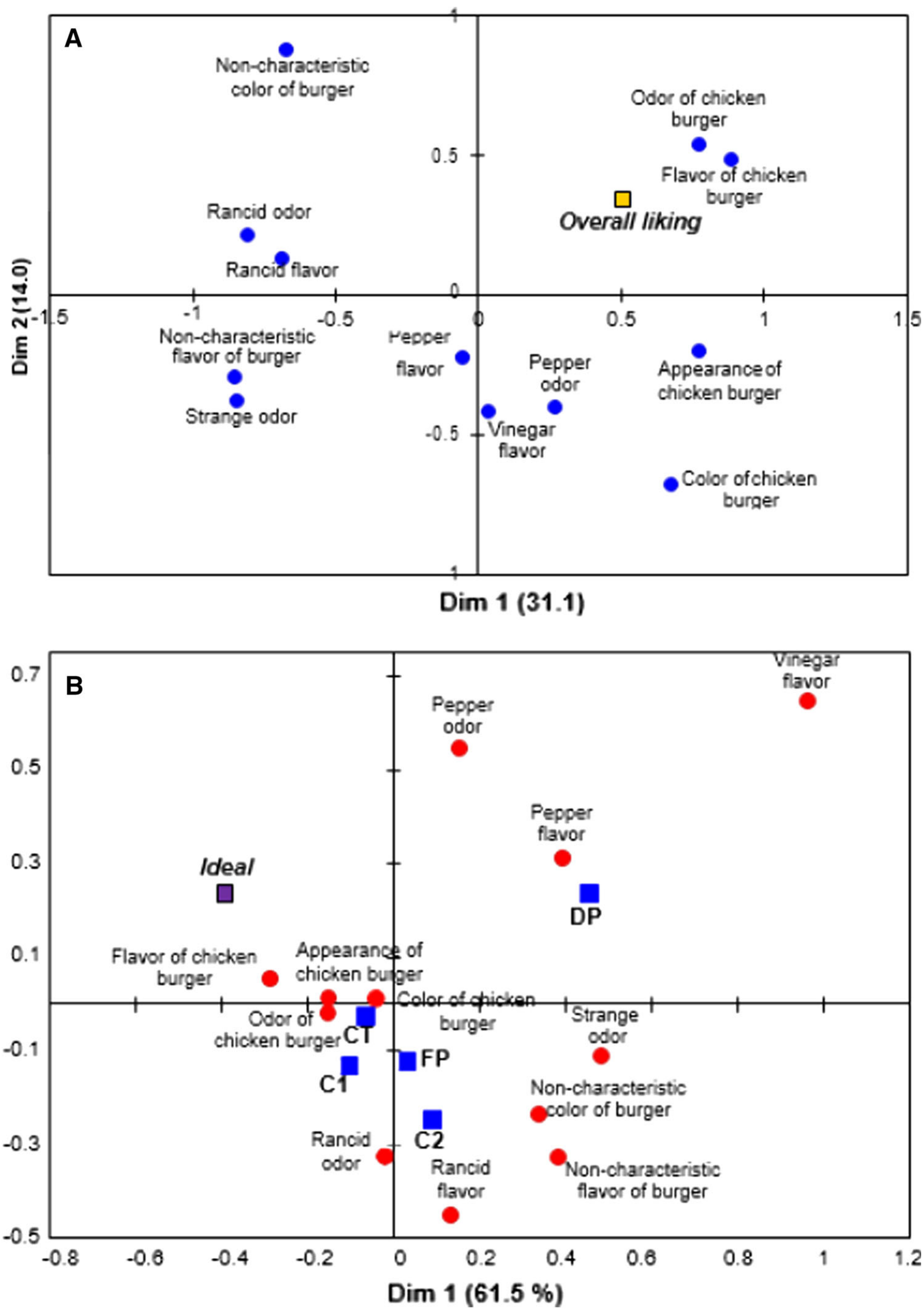
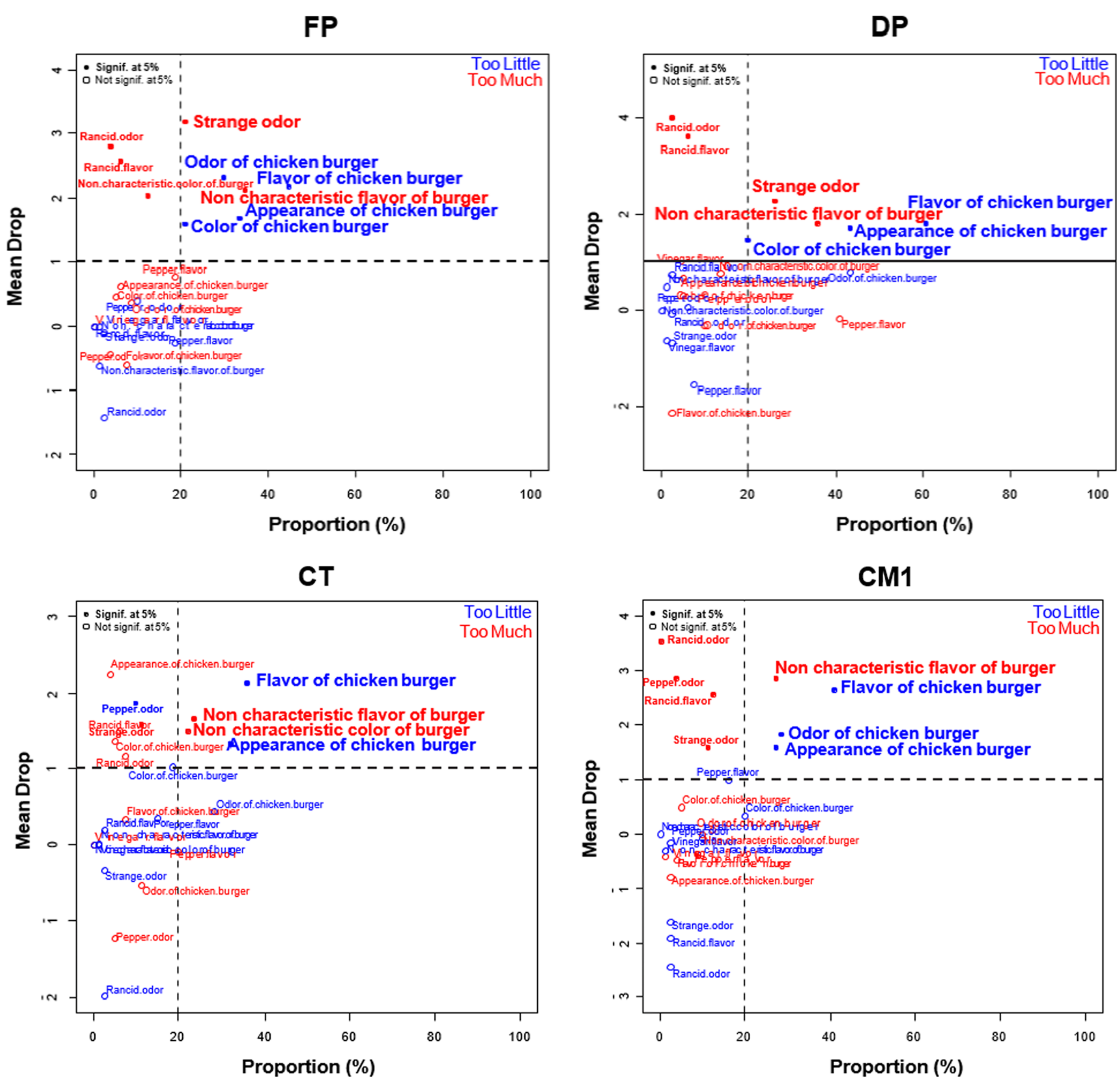
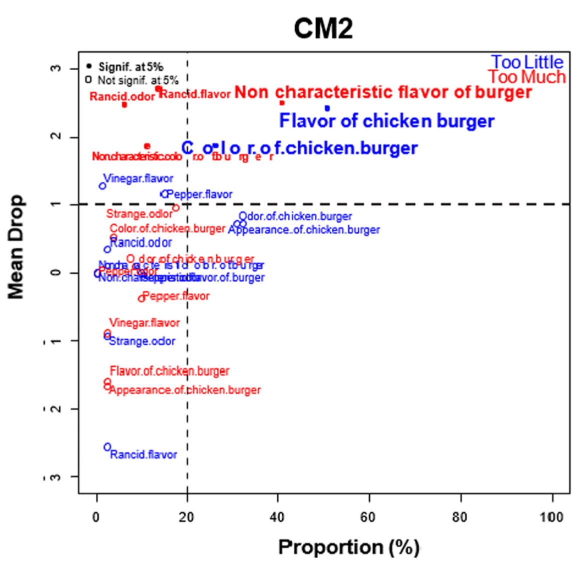


Fig. 3 **a** Principal coordinate analysis of the attributes and the overall liking data allied with the CATA questions data, **b** representation of the attributes and samples in the plane defined by the first two dimensions of CA performed on the CATA questions. Ideal sample was considered as supplementary individual. *CT* control; *DP* direct addition of PPE to the meat batter; *FP* addition of PPE to the chitosan film; and *C1* and *C2* commercial chicken burgers

the FP sample, thus being critical for consumers to perceive the burger as “ideal”: “odor of chicken burger”, “flavor of chicken burger”, “appearance of chicken burger”, and “color of chicken burger”. On the other hand, the frequency of “strange odor” and “non -characteristic flavor of burger” needs to be decreased. In Fig. 4, a table with the recommendations for increasing and decreasing the frequency of attributes was created. It is necessary to clarify that the increase/decrease of an attribute is related to the frequency of mention and not necessarily to the intensity, since the CATA data represent frequency. In general, the drivers of liking that were observed to all samples were “non-characteristic flavor of burger (To Much = decrease)” and “Flavor of chicken burger (To Little = increase)”.

In principle, burgers with PPE addition had a greater number of attributes that reduce the overall liking. However, these attributes are related to appearance, which is modified when the antioxidant extract (red color) is added, increasing the redness. Therefore, attributes associated





Sample	Main recommendations for a reformulation	
	Increase	Decrease
FP	Odor of chicken burger, flavor of chicken burger, appearance of chicken burger, color of chicken burger.	Strange odor, non -characteristic flavor of burger.
DP	Flavor of chicken burger, appearance of chicken burger, color of chicken burger.	Strange odor, non -characteristic flavor of burger.
CT	Flavor of chicken burger, appearance of chicken burger.	Non-characteristic flavor of burger, non -characteristic color of burger.
CM1	Flavor of chicken burger, appearance of chicken burger, odor of chicken burger.	Non-characteristic flavor of burger, non -characteristic color of burger.
CM2	Flavor of chicken burger, color of chicken burger.	Non-characteristic flavor of burger.

◀**Fig. 4** Mean drop of overall liking as a function of consumers who described the samples differently from the ideal sample. **a** (−) indicates that the ideal presented such attributes the samples did not, **b** (+) indicates that the samples presented such attributes the ideal did not. *CT* control; *DP* direct addition of PPE to the meat batter; *FP* addition of PPE to the chitosan film; and *C1* and *C2* commercial chicken burgers

with the product's appearance should be of concern, as they can generate negative expectations on consumers, and even induce its rejection.

Once the consumer perception was segmented, the liking of each cluster with the sensory attributes was represented (Fig. 5). Commercial samples (C1 and C2) were positioned at similar locations within the perceptual map and were preferred by cluster 1. In addition, the only driver of liking for this cluster was "rancid flavor". Cluster 2 penalized attributes related to appearance and aroma, which were on the opposite side of the DP sample. DP sample presented typical sensory attributes of the addition of pink pepper and, therefore, was rejected by consumers in cluster 2. Finally, cluster 3 preferred the samples CT and FP, which were characterized by showing "color of chicken burger" and "non-characteristic color of chicken burger". The latter attribute may be related to the myoglobin oxidation in the CT sample (without antioxidant), which lead to the darkening of the sample.

The results demonstrated that the application of antioxidants directly to the meat batter may lead to a reduction in its overall liking. Thus, the active film technology with the incorporation of extracts was shown to be a viable alternative because it helps to minimize sensory changes of chicken burger.

Conclusion

The addition of PPE in both the meat batter and the chitosan film did not affect the OL of chicken burgers. However, the cluster analysis indicated three consumer segments with different OL scores for chicken burgers. The CATA questions showed an intermediate discrimination capacity (5 of the 12 attributes evaluated). DP was highly influenced by the addition of PPE and was not considered "ideal" from the sensory standpoint. FP was sensorially similar to the commercial chicken burgers. The following attributes were regarded as the drivers of liking of chicken burgers manufactured with PPF: non-characteristic flavor of burger and the strange odor" and the "flavor of chicken burger", "appearance of chicken burger" and "color of

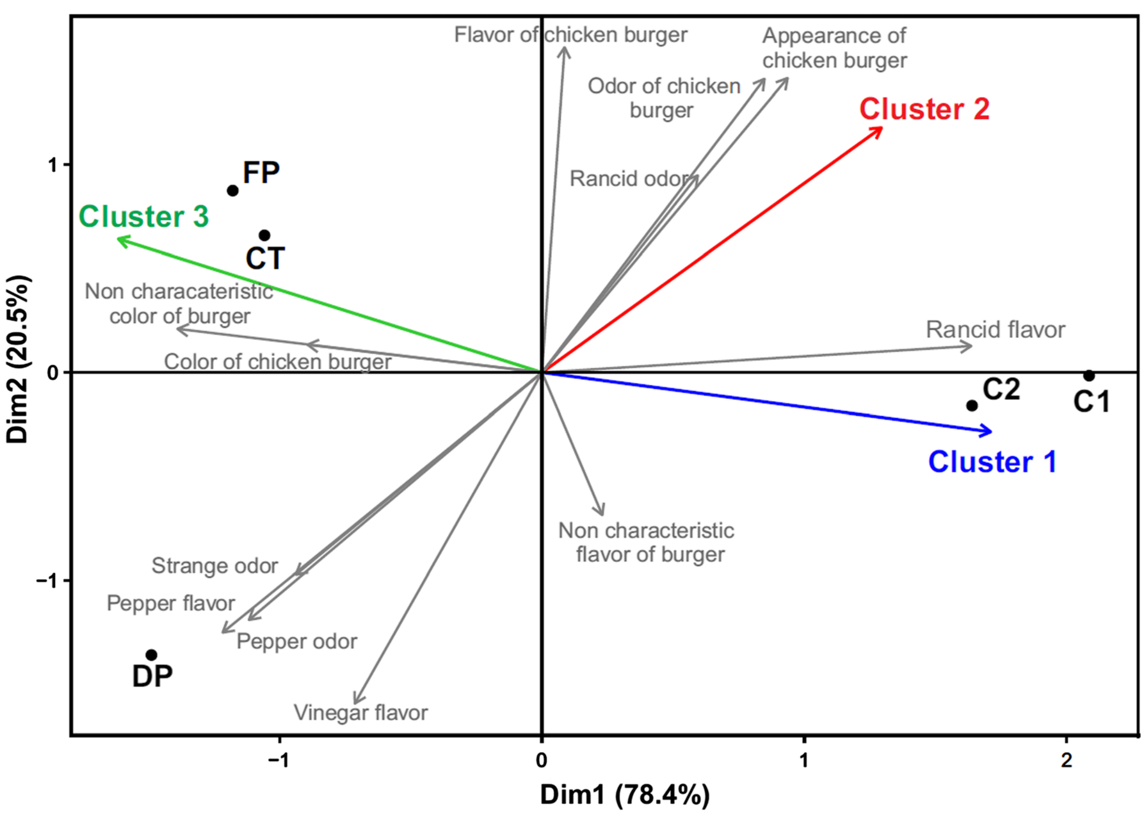


Fig. 5 Internal Preference Mapping based on the average OL per cluster. *CT* control; *DP* direct addition of PPE to the meat batter; *FP* addition of PPE to the chitosan film; and *C1* and *C2* commercial chicken burgers

chicken burger". Overall, our results demonstrated that active film technology with the incorporation of pink pepper extract is a viable alternative for replacement of synthetic antioxidants in chicken burger.

Acknowledgments Erick Saldaña received his Ph.D. Scholarship from the "Consejo Nacional de Ciencia, Tecnología e Innovación Tecnológica—CONCYTEC" from Perú (CIENCIACTIVA programme, contract agreement No. 104-2016-FONDECYT). Juan S. Serrano-León thanks the "Secretaría Nacional de Educación Superior, Ciencia, Tecnología e Innovación" (SENESCYT), Ecuador, for the scholarship and financial support.

References

Ares G, Jaeger SR (2013) Check-all-that-apply questions: influence of attribute order on sensory product characterization. Food Qual Prefer 28:141–153. https://doi.org/10.1016/j.foodqual.2012.08.016

Ares G, Jaeger SR (2015a) Check-all-that-apply (CATA) questions with consumers in practice: experimental considerations and impact on outcome. In: Delarue J, Lawlor JB, Rogeaux M (eds) Rapid sensory profiling techniques and related methods: applications in new product development and consumer research. Woodhead Publishing, Cambridge

Ares G, Jaeger SR (2015b) Examination of sensory product characterization bias when check-all-that-apply (CATA) questions are used concurrently with hedonic assessments. Food Qual Prefer 40:199–208. https://doi.org/10.1016/j.foodqual.2014.10.004

Ares G, Varela P (2017) Trained vs. consumer panels for analytical testing: fueling a long lasting debate in the field. Food Qual Prefer 61:79–86. https://doi.org/10.1016/j.foodqual.2016.10.006

Ares G, Tárrega A, Izquierdo L, Jaeger SR (2014) Investigation of the number of consumers necessary to obtain stable sample and descriptor configurations from check-all-that-apply (CATA) questions. Food Qual Prefer 31:135–141. https://doi.org/10.1016/j.foodqual.2013.08.012

Bergamaschi KB (2016) Extração, determinação da composição fenólica e avaliação do potencial de desativação de espécies reativas de oxigênio e da atividade anti-inflamatória de resíduos de amendoim, pimenta rosa e pimenta do reino (Ph.D. thesis). Universidade de São Paulo, Brazil

Brazil (2001) Agência Nacional de Vigilância Sanitária (ANVISA). Pub. L. No. Resolução- RDC no 12, de 2 de janeiro de 2001. Dispõe sobre os padrões microbiológicos para alimentos

Estévez M (2017) What's new in meat oxidation? In: Purslow PP (ed) New aspects of meat quality. Woodhead Publishing, Cambridge, pp 91–109

Gower JC (1966) Some distance properties of latent root and vector methods used in multivariate analysis. Biometrika 53:325. https://doi.org/10.2307/2333639

Jaeger SR, Ares G (2014) Lack of evidence that concurrent sensory product characterisation using CATA questions bias hedonic scores. Food Qual Prefer 35:1–5. https://doi.org/10.1016/j.foodqual.2014.01.001

Karre L, Lopez K, Getty KJK (2013) Natural antioxidants in meat and poultry products. Meat Sci 94:220–227

Lorenzo JM, Pateiro M, Domínguez R et al (2017) Berries extracts as natural antioxidants in meat products: a review. Food Res Int. https://doi.org/10.1016/j.foodres.2017.12.005

Mielby LH, Andersen BV, Jensen S et al (2016) Changes in sensory characteristics and their relation with consumers' liking, wanting and sensory satisfaction: using dietary fibre and lime flavour in Stevia rebaudiana sweetened fruit beverages. Food Res Int 82:14–21. https://doi.org/10.1016/j.foodres.2016.01.010

Morell P, Piqueras-Fiszman B, Hernando I, Fiszman S (2015) How is an ideal satiating yogurt described? A case study with added-protein yogurts. Food Res Int 78:141–147. https://doi.org/10.1016/j.foodres.2015.10.024

Nuñez De Gonzalez MT, Boleman RM, Miller RK et al (2008) Antioxidant properties of dried plum ingredients in raw and precooked pork sausage. J Food Sci. https://doi.org/10.1111/j.1750-3841.2008.00744.x

O'Sullivan MG (2017) Sensory Affective (hedonic) testing. In: O'Sullivan MG (ed) A handbook for sensory and consumer-driven new product development. Woodhead Publishing, Cambridge

Packer VG, Melo PS, Bergamaschi KB et al (2015) Chemical characterization, antioxidant activity and application of beetroot and guava residue extracts on the preservation of cooked chicken meat. J Food Sci Technol 52:7409–7416. https://doi.org/10.1007/s13197-015-1854-8

Resconi VC, Keenan DF, Barahona M et al (2016) Rice starch and fructo-oligosaccharides as substitutes for phosphate and dextrose in whole muscle cooked hams: sensory analysis and consumer preferences. LWT Food Sci Technol 66:284–292. https://doi.org/10.1016/j.lwt.2015.10.048

Rodríguez-Carpena J-G, Morcuende D, Andrade M-J et al (2011) Avocado (Persea americana Mill.) phenolics, in vitro antioxidant and antimicrobial activities, and inhibition of lipid and protein oxidation in porcine patties. J Agric Food Chem 59:5625–5635. https://doi.org/10.1021/jf1048832

Rogers L (2017) Discrimination testing in sensory science a practical handbook. Woodhead Publishing, Cambridge

Saldaña E, Behrens JH, Serrano JS et al (2015) Microstructure, texture profile and descriptive analysis of texture for traditional and light mortadella. Food Struct. https://doi.org/10.1016/j.foostr.2015.09.001

Saldaña E, de Oliveira Garcia A, Selani MM et al (2018a) A sensometric approach to the development of mortadella with healthier fats. Meat Sci 137:176–190. https://doi.org/10.1016/j.meatsci.2017.11.027

Saldaña E, Rios-Mera J, Arteaga H et al (2018b) How does starch affect the sensory characteristics of mazamorra morada?. Int J Gastron Food Sci, A study with a dessert widely consumed by Peruvians. https://doi.org/10.1016/j.ijgfs.2018.01.002

Saldaña E, Saldarriaga L, Sanchez JC et al (2018c) Descriptive analysis of bacon smoked with Brazilian woods from reforestation: methodological aspects, statistical analysis, and study of sensory characteristics. Meat Sci 140:44–50

Selani MM, Contreras-Castillo CJ, Shirahigue LD et al (2011) Wine industry residues extracts as natural antioxidants in raw and cooked chicken meat during frozen storage. Meat Sci. https://doi.org/10.1016/j.meatsci.2011.01.017

Selani MM, Shirado GAN, Margiotta GB et al (2016) Effects of pineapple byproduct and canola oil as fat replacers on physicochemical and sensory qualities of low-fat beef burger. Meat Sci 112:69–76. https://doi.org/10.1016/j.meatsci.2015.10.020

Serrano-León JS, Bergamaschi KB, Yoshida CMP et al (2018) Chitosan active films containing agro-industrial residue extracts for shelf life extension of chicken restructured product. Food Res Int 108:93–100. https://doi.org/10.1016/j.foodres.2018.03.031

Siripatrawan U, Noipha S (2012) Active film from chitosan incorporating green tea extract for shelf life extension of pork sausages. Food Hydrocoll. https://doi.org/10.1016/j.foodhyd.2011.08.011

Utrera M, Morcuende D, Ganhão R, Estévez M (2015) Role of phenolics extracting from *Rosa canina* L. on meat protein oxidation during frozen storage and beef patties processing.

Food Bioprocess Technol 8:854–864. https://doi.org/10.1007/s11947-014-1450-3
Valentin D, Chollet S, Lelie M (2012) Quick and dirty but still pretty good: a review of new descriptive methods in food science. Int J Food Sci Technol 47:1563–1578. https://doi.org/10.1111/j.1365-2621.2012.03022.x
Varela P, Ares G (2012) Sensory profiling, the blurred line between sensory and consumer science. A review of novel methods for product characterization. Food Res Int 48:893–908. https://doi.org/10.1016/j.foodres.2012.06.037
Varela P, Ares G (2018) Recent advances in consumer science. In: Ares G, Varela P (eds) Methods in consumer research, vol 1. Woodhead Publishing, Cambridge
Villanueva NDM, Petenate AJ, Da Silva MAAP (2005) Performance of the hybrid hedonic scale as compared to the traditional hedonic, self-adjusting and ranking scales. Food Qual Prefer 16:691–703. https://doi.org/10.1016/j.foodqual.2005.03.013
Worch T (2018) Ideal profile method. In: 14th Sensometrics: going further. Montevideo, Uruguay, 9–12 april, 2018