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Consumer profile and acceptability of cooked beef steaks with edible and active coating containing oregano and rosemary essential oils

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Abstract

Fresh animal products are highly perishable and characterized by a short shelf-life. Edible coatings with natural antioxidants (essential oils: EOs) could improve stability, ensure quality, and increase the shelf-life of fresh products. Due to the strong flavor of EOs, their use should consider consumer preferences and sensory acceptability. This study evaluated the effects of edible coating (with oregano and rosemary essential oil) on beef in relation to consumer preferences, besides the determination of habits of consumption and buying intentions of consumers. Acceptability scores from three clusters of consumers was described. Coating with oregano was the preferred. The higher consumer acceptance and willingness to buy this product indicate a great potential and possibility of using coatings with essential oils in fresh animal products.

Keywords: Beef acceptability, cluster analysis, principal components analysis, hedonic R index, alginate-based coating.

1. Introduction

In order to meet the demands for safe and high-quality products, the food industry needs to provide fresh products with minimum processing; ready-to-eat or requiring only minimal preparation. Moreover, with globalization and food distribution chains, fresh food products require special attention and protection during transport and storage; in addition, the desired shelf-life has to be maintained (Ahmed & Ismail, 2010; Khaleque et al., 2016).

In food preservation, different technologies are used, such as the use of enzymes from animals, bacteriocins from microorganisms, natural polymers, organic acids, edible coating, and natural compounds to replace synthetic additives (Lucera, Costa, Conte, & Del Nobile, 2012). One of the principal natural compounds which are widely used are essential oils (EOs) derived from plants such as thyme, ginger, oregano, cinnamon, clove, or rosemary. They are generally recognized as safe (GRAS), contain active compounds, and have antimicrobial and antioxidant activity (Atarés & Chiralt, 2016; Gan et al., 2016; Khaleque et al., 2016; Nieto, Jongberg, Andersen, & Skibsted, 2013; Olmedo, Nepote, & Grosso, 2013).

The choice of EOs should consider the product to which it will be applied and the consumer sensory acceptability. Due to the EOs strong flavor, their direct use is limited. However, they can be added into another matrix, such as edible coatings, which have already been suggested as alternative food packaging (Acevedo-Fani, Salvia-Trujillo, Rojas-Graü, & Martín-Belloso, 2015; Ruiz-Navajas, Viuda-Martos, Sendra, Perez-Alvarez, & Fernández-López, 2013; Vital et al., 2016). The advantages of using edible coatings with essential oils on beef products are related either to the extension of meat shelf-life, reducing the oxidation or microorganism spoilage during display

(Acevedo-Fani et al., 2015; Ruiz-Navajas et al., 2013, Vital et al., 2016) or to the substitution of synthetic compounds by natural products. Consumers prefer the intake of natural products, decreasing the ingestion of chemical compounds that are not desirable. Besides, there is a possible antioxidant effect of those natural compounds on the body if they are still bioavailable after digestion (Lorenzo, González-Rodríguez, Sánchez, Amado, & Franco, 2013; Vital, Croge, Gomes-da-Costa, & Matumoto-Pintro, 2017). Consumer preferences or needs should also be considered when a new product is proposed (including the application of edible coating to animal products), since preferences may vary between individuals, groups, cultures, segments, and interests (Baba, Kallas, Costa-Font, Gil, & Realini, 2016; Ngapo, Martin, & Dransfield, 2007; Nielsen, Bech-Larsen, & Grunert, 1998; Vasconcellos et al., 2013). Additionally, adapting to new products, mainly internationally, brings the necessity to learn more about consumer preferences before a wider distribution (Van Kleef, Van Trijp, & Luning, 2005). When a new product or technology is proposed it is essential to know all its possible markets, groups of buyers, and possible failures. The current study investigates the profile of potential consumers of beef with edible coating and gives information about the potential niche markets, according to consumers' habits and preferences, differing from other studies that evaluated only the general acceptance of the product.

Knowing why consumers chose a product is important to evaluate their motivation for consuming and buying it and to determine whether there are any barriers. However, quality or value are not the only reasons for buying or consuming certain products, and consumers' attitudes or motivations are usually affected by a complex group of factors (Olsen, Heide, Dopico, & Toften, 2008). For these reasons, product sensory evaluation and the knowledge about a population consumption habits are

important. Understanding how consumers form and perceive attitudes in relation to new technologies and products is important for food chain innovation, since consumer acceptance is crucial to the development of successful food products (MacFie, 2007).

Thus, this study investigated consumer acceptance of beef with edible and active coating and different essential oils. Our aim was to provide insights into consumers' socio-economic and demographic characteristics as well as their consumption habits and factors that influence their purchasing intention.

2. Material and methods

2.1. Product selection and preparation

2.1.1. Beef preparation

The steaks were obtained from four young crossbred bulls (½ Angus *vs.* ½ Nellore) from a single father, finished in a feedlot (187 days) and slaughtered at 12 months old (443.5 $\pm$ 26.2 kg).

The carcasses were chilled at 4 ºC for 24 h after slaughtering. The *Longissimus thoracis* (LT) was excised from the left half of the carcass from the seventh to the last lumbar vertebra, transported to the Laboratory, vacuum-packaged, and frozen intact at -18 ºC until analysis (less than 1 month of storage).

The LT were then thawed (4 ºC for 24 h) and homogenous steaks (2.5 cm) and distributed randomly for experimental treatment and analysis.

2.1.2. Preparation of coating solutions and treatments

Coating was prepared according to Groppo, Spoto, Gallo, and Sarmento (2009) modified by Vital et al. (2016). The sodium alginate (2% w/v) was dissolved in sterile distilled water (70 °C). After the complete dissolution, the alginate solution was chilled (25 °C). For the active coating, the EOs (Ferquima®) were added to alginate solution and mixed under magnetic stirring. Beefs were divided into four treatments: uncoated beef (CON); beef with edible coating (EC); beef with edible coating containing 0.1% (v/w) of rosemary EO (ECR) and beef with edible coating containing 0.1% (v/w) of oregano EO (ECO). The steaks (8 of each animal) were submerged in alginate solution, individually, during 1 min. After the stakes were allowed to drain (in order to remove the coating excess) during 1 min, and then, submerged in a crosslinking solution - calcium chloride solution (2% w/v) during 30 s. The samples were packaged in polystyrene tray, wrapped with a retractile film and stored at 2 ± 1 °C for one day. The main components of EOs were: 1,8-cineol = 47.51%, camphor = 16.7% and α-pinene = 13.5% for rosemary oil; and carvacrol = 70%, o-cymene= 9.45%, γ-terpinene= 8.0% for oregano oil.

2.2. Consumer test designs

The consumer test was performed in a private room (adequately adapted to perform a sensory test) at the Universidade Estadual de Maringá (Brazil). Consumers were randomly selected (students, employers, and visitors) according to gender and age (from 18-24 years, from 25-39 years, from 40-54 years, and > 55 years), according to the Brazilian national profile (IBGE, 2015). The socio-economic data, the level of education and family income was also collected (Table 1).

Consumers were divided by session, with 10 persons in each session. For beef acceptability, there were 9 sessions (n of total consumers: 90). Per session, consumers evaluated four samples identified with a three-digit code, corresponding to the four different treatments CON, EC, and the two EC with essential oils (oregano and rosemary). To avoid order and carry-over effects samples were served in a randomized design (Macfie, Bratchell, Greenhoff, & Vallis, 1989).

For beef preparation, each steak was covered with aluminum foil and cooked in a pre-heated grill (200ºC) (Philco Grill Jumbo Inox, PHILCO S.A., Brazil) until an internal temperature of 70 ºC was reached. Each steak was then cut (2 x 2 cm cubes), wrapped in aluminum foil, and kept at 50ºC until consumer evaluation (soon after cooking).

The consumer analysis was approved by the Committee on Ethics in Research, Universidade Estadual de Maringa, PR, Brazil with a protocol number: CAAE: 58879716.7.0000.0104.

2.3. Questionnaire

Participants were requested to taste each individual sample and evaluate on each the acceptability of the four studied attributes: odor, tenderness, flavor, and overall acceptability, with a 9-point scale, from 1 (dislike extremely) to 9 (like extremely), and the medium level was not included, according to Font i Furnols et al. (2008). The consumers were informed to eat toasted bread (unsalted) and drink water to rinse their mouths before taste each sample, including the first one.

Prior to consumer testing, a supplementary questionnaire was applied in order to gather more information about consumption habits (Table 2), buy preferences, or the

willingness to buy beef with edible and active coatings (Table 3). It included closed questions with multiple choices.

2.4. Statistical analysis

Acceptability of the sensory attributes was assessed via analysis of variance using general lineal model (GLM) procedures with SPSS (15.0) for Windows. Treatments were considered a fixed effect and the consumer a random effect on the sensorial test; session was considered a blocking effect.

Differences between means were evaluated using Duncan's test ($P \leq 0.05$). Hierarchical cluster analysis with the Ward's method was used to determine the different segments of consumers, according to the overall acceptability using XLSTAT (v.7.5.3). The number of clusters was selected by a dendrogram. Principal Components Analysis (PCA) was used to verified the relationships between treatments and the acceptably attributes and showed in a graphic. Hedonic R index was calculated according to Wichchukit and O'Mahony (2015) to measure the degree of preference between the different treatments. Mean and standard error of mean (SEM) were calculated for each variable.

3. Results and discussion

3.1. Socio-demographic characteristics, consumption and purchasing habits of consumers

The questionnaires applied increased the information in relation to consumers' preferences and habits of buying and consumption. Consumer demographic and socio-economic characteristics are presented in Table 1. For beef testing, consumers were composed of 51.1% men, with the majority of consumers being younger than 40 years old, according to the Brazilian national profile. Most participants had completed high school or were in the process of completing (42.2%). Household incomes among participants were primarily in the range of 2 to 6 minimum income (788 Brazilian Real or 240 US $) (55.6%).

Consumption habits of beef consumers are presented in Table 2. Main beef consumption was two to four times per week and more than five times per week (49.4 and 34.4%, respectively). In comparison, pork was consumed once a week (45.6%) and lamb once a month (75.0%). The high frequency of poultry consumption (2-4 times/week) could be explained by its low price (lower than other meats) and by the Brazilian eating habits (Carvalho, César, Fisberg, & Marchioni, 2014).

Answers related to beef consumption habits were not unexpected; the high consumption of beef has already been reported in other consumer tests carried out in Brazil (Carvalho et al., 2014; Carvalho, César, Fisberg, & Marchioni, 2012; Kirinus, Fruet, Klinger, Dörr, & Nörnberg, 2013), and the frequencies are in agreement with the national official consumption data from ANUALPAC (2015) and FAPRI (2016). Beef is a traditional product in the Brazilian culture and with the economic changes and the development, there was an increase in purchasing power (Kirinus et al., 2013), enabling the general population to buy other types of meat for consumption.

Meat was mainly bought in the supermarket (67.8%), followed by traditional shops such as butchers (31.1%). Beef consumers preferred to buy fresh cuts (84.4%). The price was the second most important factor in beef selection (32.2%) after color

(62.2%), showing that productive factors have a low importance in the purchase preference.

Almost half of the participants (48.9%) had never consumed a product with edible coat and was unaware of this technology; however, the majority of consumers knew essential oils and expressed their willingness to purchase meat that contains essential oils. In addition, consumers were prepared to pay more for beef with edible coats and essential oils. Although most consumers did not know the technology of coating, most of them were familiar with essential oils, which are natural products. Therefore, due to the current concern about a healthy diet, products that contain natural compounds (rather than synthetic ones, for example) are preferred, and consumers may have associated the benefits of essential oil with the product, considering positively its purchase at a higher price.

In relation to the spices used in food preparation, oregano was the one that most consumers affirmed to use in the preparation of food (74.4%); however, rosemary had lower frequencies of use (22.2%).

Food choice results from the interaction between different factors involving economic, social, individual, and cultural aspects (Vabø & Hansen, 2014). Although consumers generally demonstrate a certain level of resistance to adopting new or unfamiliar food products (Barcellos et al., 2010; Verbeke, 2015), a presumable good acceptability and willingness to pay a higher price indicated by consumers (Table 3). Besides that, the use of herbs, natural compounds, and additives of natural origin is well accepted by consumers, which considered those kinds of products safe and familiar and showed a positive use as replacers of synthetic food additives (Haugaard, Hansen, Jensen, & Grunert, 2014; Hung, de Kok, & Verbeke, 2016; Koyratty, Aumjaud, & Neeliah, 2014).

3.2. Consumer preferences and R index

One way to evaluate consumer acceptance is through the R index (Table 4), which compares the preference of one sample in relation to another (Wichchukit & O'Mahony, 2015). For beef samples, ECO was the most preferred treatment, obtaining 63.02, 64.76, and 62.23% of preference in relation to CON, EC, and ECR, respectively.

According to Ojagh and others (2010), coatings enriched with essential oils used as natural preservatives should not introduce negative effects on the sensory attributes. In this study coatings with essential oil did not produce undesirable sensory properties; on the contrary, coated beef with oregano was the most preferred in relation to the others (Table 4). Khaleque et al. (2016) studied the use of clove and cinnamon essential oil in ground beef and consumers from Latin America rejected the products, with acceptability for meat with 5 and 10% of clove essential oil. This result could be associated with the flavor incompatibility of the meat-clove flavor blend and the high percentage of essential oil in the sample. On the other hand, as reported by Vital et al., 2016, the inclusion of oregano/rosemary on beef with coating had a significant effect on consumer general acceptability, and oregano essential oil achieving the highest scores.

Du et al. (2012) reported that consumers are widely exposed to a flavor blend, and some products are more commonly associated with a specific spice. Oregano, for example, is added to a variety of foods, which can favor its sensorial acceptability. As reported by consumers in the questionnaire, most used oregano in food preparation, which may explain the preference for samples with edible coating and oregano. Nevertheless, oregano coated-beef showed the lowest oxidation though display (Vital et

al., 2016), even after only one day of display, which may also influence the consumer preference towards a less oxidized meat.

Brazil is a multicultural country, as is the city where this study was developed; this fact could partially explain the good acceptability for the products with edible coating. As previously reported (Barcellos et al., 2010; Olewnik-Mikołajewska, Guzek, Głąbska, & Gutkowska, 2016), in a mixed culture, exposure to ethnic food products and dishes reduces food neophobia, thereby positively impacting the adoption of new products, although a more traditional behavior could be also expected due to the existence of conservative consumers with strong regional or cultural roots, as observed in the cluster analysis.

3.3. Cluster analysis

Resulting from different consumer studies (Font-i-Furnols & Guerrero, 2014; Oliver et al., 2006), perceptions and preferences in relation to acceptability of a product attribute are not homogenous among a consumer group (clusters). Those differences also occur when consumption habits, preferences for choice, and attitudes to certain attributes are considered (Realini et al., 2013; Schnettler, Vidal, Silva, Vallejos, & Sepúlveda, 2009); such information is important in order to identify different market niches. In Table 5, acceptability scores from three clusters of consumers for beef are described in terms of odor, flavor, and overall acceptability.

3.3.1. Odor acceptability

In terms of beef odor, there were three groups of consumers (Table 6). Cluster 1 was characterized by rejecting odor acceptability of all samples, especially those with edible coat with or without essential oils; however, due to the small numbers of participants (5.5%), differences between treatments were not significant. This sample was composed of 60% men and 40% women, all younger than 24 years.

The second cluster represented the 25.6% of consumers who preferred ($P \leq 0.001$) the odor of beef with edible coat and essential oils (ECO and ECR) in relation to the control group (which was rejected), with an intermediate acceptability for the edible coat without essential oils. The percentage of men and women was similar on this group (52.2 *vs.* 47.8%, respectively); 73.3% were younger than 40 years. For the third group, despite the aromatic characteristics of some treatments, 68.9% of consumers did not reported differences based on odor acceptability between samples, with all treatments having a high acceptability (between 6.8-7.2 points on a 9-point scale). Men and women of this cluster were in the same proportion, 50.0%, with 54.8% of them being younger than 24 years and 25.8% between 25 and 39 years.

3.3.2. Flavor acceptability

All clusters of consumers reported differences ($P \leq 0.010$) in flavor acceptability between treatments for beef (Table 5).

Cluster 1 (25.6%) gave the best scores to treatments without essential oils (CON and EC), with oregano essential oil having a better flavor acceptability than rosemary oil, which was rejected. This cluster contained 34.8% men, with 75% of them being younger than 24 years.

Cluster 2 (27.8%) preferred the flavor of samples with both essential oils compared with CON and EC which presented scores lower than 5 points. This segment of the population consisted of 52% men and 48% women; 88% were younger than 40 years.

Cluster 3, which compiled the main part of the consumers (46.6%), was characterized by high acceptability of flavor for all treatments (over 7.1 points), with EC being significantly less accepted than ECO. In this cluster, 59.5% of consumers were men and 20% of them older than 55 years. The 70.6% women were younger than 25 years.

3.3.3. Overall acceptability

There were statistically significant differences between treatments ($P \leq 0.010$) in the three clusters in overall acceptability. In this appraisal, 24.4% preferred the essential oil treatments rather than CON or EC, with an acceptability lower than 4.6 points. In this cluster, 45.5% were men; 70% were younger than 24 years and no participant was older than 55 years; however, only 16.7% of women were included in this.

Cluster 2, with 20% of consumers, gave the highest acceptability to treatments without essential oils (CON and EC). Rosemary edible coat was rejected (4 points) and oregano obtained an intermediate acceptability. This cluster was formed by 66.7% of women and 78% of the participants were younger than 40 years.

The third and most significant cluster (55.6% of consumers) gave all treatments scores higher than 7.1, with ECO being better accepted than those with edible coating without essential oils. The participants of this group were 60% men, and 82% were younger than 40 years.

3.4. Principal components analysis

Information about coating and preferences by consumers is graphically shown in Figure 1. The two principal components axes explained 98.69% of the total variance for beef. The attributes of flavor, odor, tenderness, and overall acceptability are situated on the right-hand side of F1, located close to ECO. The other treatments (CON, EC, and ECR) are on the other side (left to F1), inversely related to the attributes assessed. Odor is situated in the same quadrant as ECO, which demonstrates an association between these two factors (Fig. 1). Vital et al. (2016) already showed the lowest oxidation of ECO, that may favor a lower development of off-odors and off-flavors that could lead to a rejection by the consumer. Lipid oxidation values never reached values close to a perception that could lead to reject this treatments (Campo et al., 2006), but the lowest values could have influenced a higher acceptability. Besides that, at one day of ageing, differences in shear force between treatments were observed due to the effect of coating on itself, but not to the addition of essential oils (Vital et al., 2016). This might explain why ECO was more related to odor and flavor acceptability than to tenderness.

4. Conclusion

In this study, the incorporation of edible coating with essential oils had a significant influence on beef acceptability. Beef with edible coating with 0.1% of oregano essential oil was the most preferred. The higher consumer acceptance and willingness to purchase these products indicate a great potential and the possibility of using edible coating with essential oils in a variety of fresh animal products.

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Figure Captions

Figure 1. Principal component analysis of the scores for odor, flavor, tenderness and overall acceptability of beefs with and without edible coatings. CON: Control without edible coating; EC: Beef with edible coating; ECR: Beef with edible coating and rosemary essential oil; ECO: Beef with edible coating and oregano essential oil.

Table 1. Socio-demographic characteristics of the consumers (*n*=90).

	Beef consumers		
	Total population	Men	Women
Age	(%)	(%)	(%)
< 24 y.	58.9	60.9	56.8
25-39 y.	22.2	17.4	27.3
40-54 y.	7.8	10.9	4.5
> 55 y.	11.1	10.9	11.4
Total %	100	51.1	48.9
Total (n)	90	46	44
Socio-economic		Beef consumers (%)	
Familiar income: minimum wage (MW)	Until 2 MW	12.2	
	From 2 to 6 MW	55.6	
	From 6 to 10 MW	18.9	
	Higher than 10 MW	13.3	
Level of education	Primary School incomplete	4.4	
	Primary School complete	1.1	
	Secondary School incomplete	1.1	
	Secondary School complete	8.9	
	High School incomplete	42.2	
	High School complete	42.2	

* MW: minimum wage (2015-2016): 788 Brazilian Real = 240 US$.

Table 2. Consumers habits of consumption (*n*=90).

Frequency of consumption	Answers	% Beef consumers
Beef	1 time/ month	3.4
	2 times /month	1.1
	1 time/ week	11.2
	2 - 4 times/week	49.4
	More than 5 times/week	34.8
Pork	1 time/ month	25.3
	2 times /month	17.7
	1 time/ week	45.6
	2 - 4 times/week	8.9
	More than 5 times/week	2.5
Poultry	1 time/ month	5.6
	2 times /month	7.9
	1 time/ week	27.0
	2 - 4 times/week	50.6
	More than 5 times/week	9.0
Lamb	1 time/ month	75.0
	2 times /month	11.5
	1 time/ week	9.6
	2 - 4 times/week	1.9
	More than 5 times/week	1.9

Table 3. Consumer preferences and habits of purchase (*n*=90).

	% Beef consumers	
Place where buy beef	Butcher	31.1
	Supermarket	67.8
	Meat boutique	1.1
How do you prefer to buy beef?	Fresh cut	84.4
	Vacuum packed	10.0
	On tray	5.6
The most important factor when buy beef	Price	32.2
	Color	62.2
	Age of animal	1.1
	Breed	1.1
	Other	3.3
Do you already eat some product with edible coat?	Yes	48.9
	No	51.1
Do you know the utility/function of edible coats?	Yes	38.9
	No	61.1
Do you know what essential oils are?	Yes	70.0
	No	30.0
Essential oils are natural products. Did you buy beef with the addition of this kind of products?	Yes	82.2
	No	17.8
Are you willingness to pay more for beef with edible coat and essential oil?	Yes	57.8
	No	42.2
Do you use oregano on food preparation?	Yes	74.4
	No	25.6
Do you use rosemary on food preparation?	Yes	22.2
	No	77.8

Table 4. Hedonic R index for beef with edible coating assessed by consumers.

Beef consumers (*n*=90)	%
Prefer CON to EC	51.25
Prefer CON to ECR	49.45
Prefer CON to ECO	36.98
Prefer EC to CON	48.75
Prefer EC to ECR	48.22
Prefer EC to ECO	35.24
Prefer ECR to CON	50.45
Prefer ECR to EC	51.78
Prefer ECR to ECO	37.77
Prefer ECO to CON	63.02
Prefer ECO to EC	64.76
Prefer ECO to ECR	62.23

CON: Control without edible coating; EC: Beef with edible coating; ECR: Beef with edible coating and rosemary essential oil; ECO: Beef with edible coating and oregano essential oil.

Table 5. Mean and standard error of acceptability scores of beef with edible coating among three consumer groups that were identified by cluster analysis (n=90)[§].

	n	%	CON	EC_b	ECR_b	ECO_b	SEM	P < value
Odor acceptability								
Cluster 1	5	5.55	4.40	2.40	2.40	3.60	0.337	0.135
Cluster 2	23	25.56	4.04^{c}	5.17^{b}	6.22^{a}	7.04^{a}	0.196	<0.001
Cluster 3	62	68.89	7.27	7.11	6.87	7.13	0.079	0.280
Flavor acceptability								
Cluster 1	23	25.55	7.0^{a}	7.17^{a}	3.52^{c}	5.52^{b}	0.217	<0.001
Cluster 2	25	27.78	4.32^{b}	4.64^{b}	5.84^{a}	6.76^{a}	0.200	<0.001
Cluster 3	42	46.67	7.45^{ab}	7.17^{b}	7.43^{ab}	7.8^{a}	0.072	0.004
Overall acceptability								
Cluster 1	22	24.44	3.77^{b}	4.64^{b}	5.68^{a}	6.50^{a}	0.200	<0.001
Cluster 2	18	20.00	7.11^{a}	7.39^{a}	4.00^{c}	5.61^{b}	0.227	<0.001
Cluster 3	50	55.56	7.40^{ab}	7.12^{b}	7.40^{ab}	7.68^{a}	0.063	0.006

a,b: indicate statistical differences in the same line ($P \leq 0.05$).
§Based on a 9-point scale (1: dislike extremely; 9: like extremely). SEM: Standard Error of Mean
CON: Control without edible coating; EC: Beef with edible coating; ECR: Beef with edible coating and rosemary essential oil; ECO: Beef with edible coating and oregano essential oil.

Highlights

- Effect of edible coating with essential oils on consumers' preferences of beef.
- Oregano and rosemary essential oils (EOs) were used in coating.
- The alginate-based edible coatings did not affect negatively sensorial acceptance.
- Edible coating with oregano had the best scores in consumer tests.

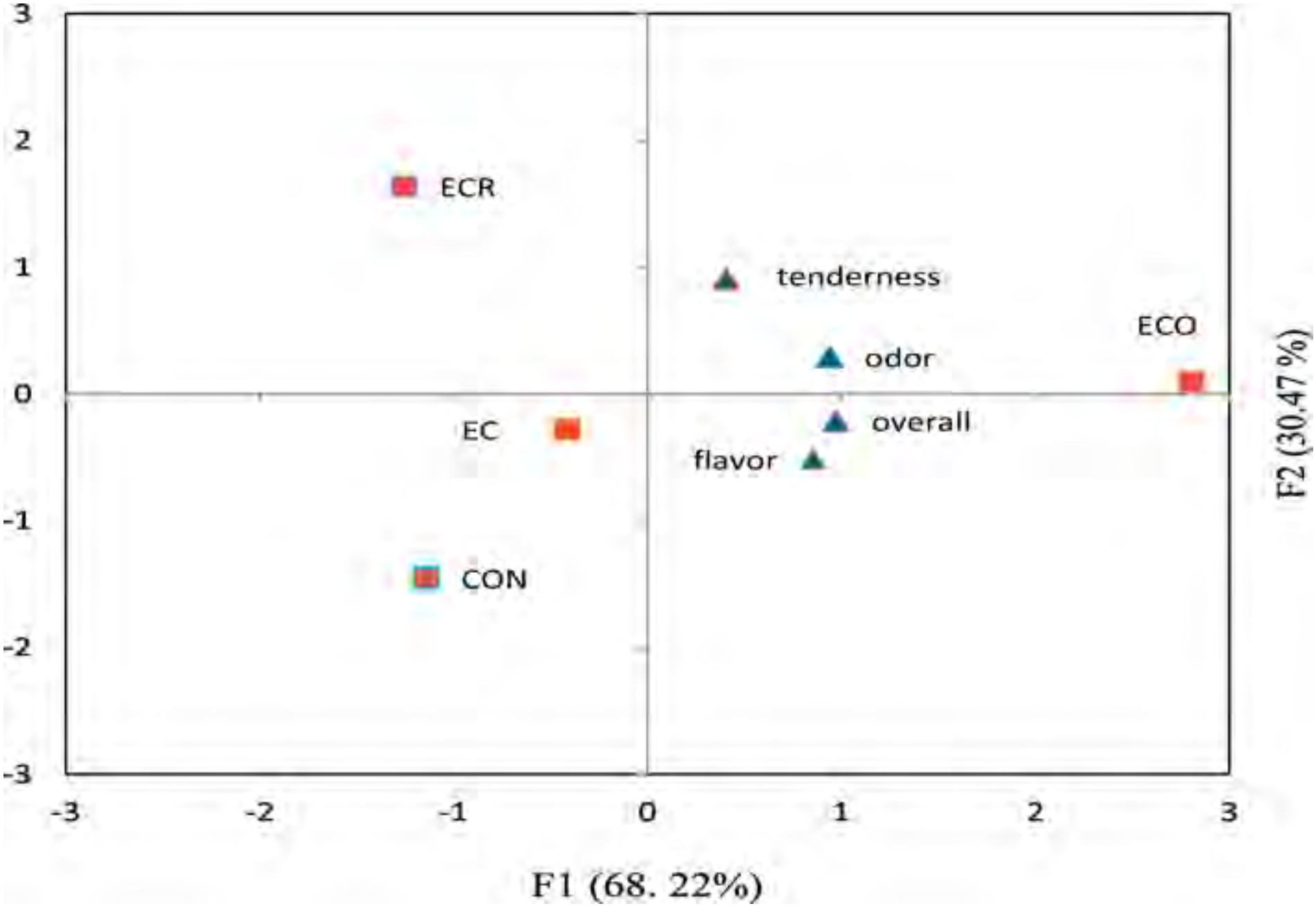
ECR
tenderness
ECO
odor
overall
EC
flavor
CON
F2 (30.47 %)
F1 (68. 22%)
3
2
1
0
-1
-2
-3

Figure 1