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STATISTICAL STUDIES ON THE LEXICON USED IN SENSORY EVALUATION OF SOY-ADDED BEEF HAMBURGER

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Abstract: *The aim of this paper was to study consumers' perception of three samples of soy - added beef hamburger in different percentages, using some helpful methods to capture consumers' perception sensory characteristics, such as free listing, check–all-that-apply (CATA) question and intensity scaling in order to determine the intensity of some sensorial characteristics (taste, odor, flavor and texture). For this purpose we prepared three samples of soy-added beef hamburger in different percentages (25%, 50% and 75% soy bean of total mass) and we study the effect of soy addition in beef hamburger on the sensory properties was studied.*

Keywords: *Check-all-that-apply (CATA), free listing, lexicon for sensory characterization, sensory evaluation, hamburger*

1. Introduction

Sensory characteristics such as odor, taste, appearance, flavour and texture are important quality factors of food products industry. Tools that describe data regarding consumer liking are sensory lexicons and descriptive sensory profiling methods, used to capture consumers' perception of food products. Moreover, methods such as free listing and check–all-that – apply (CATA) are increasingly used in sensory analysis, because they can be helpful for information that could be used to develop new food products [1]. With these tools, we could start new studies to determine which sensory attributes drive consumers' satisfaction and determine the perception of potential consumers.

A free listing method is used to develop a lexicon describing the product space.

CATA is a method used in the food sensory evaluation to gather information about sensory and non - sensory perception, based on the selection of appropriate words from a predefined list of descriptors. Also, CATA method can be used to determine the perception of product sensory attributes and it may lead to a better product differentiation among food products of the same category [2].

CATA has been applied in analyzing many food products, such as: salty snacks [3], strawberry cultivars [4], vanilla ice cream [5], chocolate milk dessert [6-7], orange-flavored powdered drinks [6-7] and texture perception of milk desserts [8].

We applied the above mentioned methods to capture consumers' perception of sensory characteristics of soy protein - added beef hamburger.

Hamburgers most likely first appeared in the 19th or early 20th centuries, they were firstly made in Hamburg, Germany [9]. They are usually regarded a feature of fast food restaurants, where they are grilled on a flat-top or on a gas flame grilling process [10].

Still the addition of soy in ground beef has some advantages and disadvantages for hamburgers' production.

First of all, several reasons that justify the advantages of the addition of soy protein in ground beef hamburger can be the following:

- the consumers' demand for healthier meat products that are generally low in fats and calories and contain in addition health-promoting bioactive components [11];
- soy is considered healthful, contains well balanced amino acids, being a source of protein [12];
- detectable amounts of soybean lecithin were found in soy-based edible products such as hamburgers [13];
- textured soy protein content was found to be the most important factor to minimize fat and moisture loss of hamburger patties after cooking [14];
- soybean proteins can act as emulsifiers in preventing coagulation of fats during heating of the meat when the content of lean meat is low [15];
- soy paste is a non-meat protein source which has a great potential use in the manufacture of emulsion type meat products with good acceptability and cost benefit [16];
- soybeans have a low beany flavor, better color and consistency with a composition of 77.43% moisture, 13.09% protein and 5.95% fat [17].

On the other hand, the use of soy as a food has been limited because of its odor generated during processing, known as "bean odor" or "smell of green beans" [18].

2. Material and Methods

The descriptive analysis was used to define and quantify the sensory characteristics ascertained by panelists who provided intensity ratings for a set of selected attributes. It involves three main steps [19].

In the first step, a lexicon that describes the product space was developed, where synonyms were regrouped in a single term, using a free listing as a simple qualitative technique [20].

Introduced to food consumer science by Hough and Ferraris, in 2009, [20-21], the free listing method is a qualitative technique, used for the first time specially in anthropology by Rusell Bernard, in 2005, [22], which consists in asking participants to ''list all the X they know about the studied product".

In the present study 50 participants recruited from students of the Faculty of Food Engineering, Stefan cel Mare University of Suceava, Romania, ranging in age between 18 and 26 years old, 76% female and 24% male, were asked to list some sensory characteristics of hamburger.

In the second step, the panelists were familiarized with the sensory concepts of the panel (using ISO 5492: 2008 and [23-24]).

The terms obtained using free listing method, identified as most relevant for consumers, have been used during consumer studies from the third step, in which the intensity scale or CATA questions methods were considered to evaluate the sensory characteristics of soy-added beef hamburger in different percentages (25%, 50% and 75%, respectively).

The third step consists in tasting the three samples by each taster. The sensory analysis phases took the following steps:

1. Sampling samples of the same type was made to obtain identical samples in terms of quantity, shape, consistency, color, appearance and temperature; the sensory samples analyzed should be similar to each other.
2. Presentation of samples: sample temperature ranged between 60 and 65 ^{0}C. Samples were coded (with three digit numbers) so that the tasters could not get any information regarding the identity of the sample. Evaluators were given three versions of the product to be tasted (hamburger with 25% soy, 50% soy and, 75% soy respectively).
3. Appreciation of descriptors was made using a 6 - point value scale for taste, odor and flavor of soy in hamburger, from 0 to 5, ordered by intensity (where 0 is equivalent to the absence of perception and the 5 represents the maximum intensity). Also, the influence of soy on the texture of hamburger, using a 5 - point value scale from 1 to 5, ordered by intensity (where 1 corresponds to soft texture and 5 corresponds to 5 texture) was study.
4. While the testing sessions ran on, evaluators marked on a scale of intensity, based on the terms of the check-all-that-apply (CATA) question list.
5. Statistical analysis of results was made according to ISO 11035:2007 and ISO 4121:2008.

Samples were made as follows: the first hamburger sample consisted of 75% beef and 25% soy, the second hamburger sample consisted of 50% beef and 50% soy and the third one consisted of 25% beef and 75% soy respectively. 1500 g of ground beef, 1500 g dry soy granules (hydrated with water), salt and pepper were used to prepare the samples. A mixture was prepared from these ingredients, but with different amounts of soybean and beef, as follows: sample 1 contains 750g ground beef and 250g soy granules, sample 2 contains 500g ground beef and 500g soy granules and sample 3 contains 250g ground beef and 750g soy granules.

These raw materials and ingredients were well mixed, allowed to stand for 10 minutes, afterwards meat patties were formed. After having been prepared, the hamburgers were cooked on the grill.

Figure 1 shows sections of hamburgers cooked on the grill.

a). b). c).

Figure 1. Section of hamburgers prepared with addition of:
a). 25% soy (Sample 1), b). 50% soy (Sample 2), c. 75% soy (Sample 3)

Three samples of beef hamburger were evaluated by 10 assessors (50% female and 50% male), recruited from students of the Faculty of Food Engineering, Stefan cel Mare University of Suceava, Romania, ranging in age between 22 and 26 years old. Samples were presented nomadically and water was available for rinsing between samples.

To obtain more accurate data sensory examination was performed in a bright, clean room, free from foreign odors and at room temperature of about 20^0 C.

Sensory examination was

performed in daylight and did not alter the colors of the products (ISO 6658:2007). The plates with samples have been placed side by side on a white surface. The sensory characteristics appreciated in the examination session of soy-added hamburger were the following: smell, taste, color and texture. Samples were coded with different 3-digit codes and were served at room temperature in a randomized order.

Principal component analysis (PCA) of data was computed for sensory analysis of samples. All analyses were performed by using the software program XLSTAT (trial version 2013.10.08, © Addinsoft).

3. Results and Discussion

The results obtained using free listing method consists of all the words elicited by participants. A search for recurrent terms was performed, grouping different word classes for the same term (i.e. adjectives and nouns) [22]. Only the most frequently mentioned 5 terms were considered in our analysis. Thus, we obtain a list of word which can describe taste (oily, metallic, raw, prick, frying), odor (fried, soy milk, rancid, caramel, bean), flavor (cereals, dried, boiled, cooked on the grill, no flavour), texture (soft, hard, elastic, wet, dry) and appearance respectively (fresh, appearance densely, homogeneous composition, crunchy, crumbly) of soy-added beef hamburgers.

The data analysis resulted from the testing sessions contains two parts.

In the first part, the panelists scored the products sensory characteristics (taste, odor, flavor and texture) on the basis of each descriptive attribute on a 6 - point intensity scale for taste, odor, flavor, and 5 - point intensity scale for texture respectively. Table 1 shows the results (mean ± standard deviation) regarding the influence of soy addition on the taste, odor, flavor and texture of hamburger, in terms of intensity of soy taste, odor, flavor (0 = imperceptible, 1 = very low, 2 = low, 3 = medium, 4 = relatively strong, 5 = strong or very intense) and texture (1 = very soft, 2 = soft, 3 = medium, 4 = hard, 5 = very strong).

Table 1.
The score obtained in terms of intensity soy presence in sensory characteristics of soy-added hamburger in different percentages (25% for Sample 1, 50% for Sample 2 and 75% for Sample 3)

Samples	Taste		Odour		Flavour		Texture	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Sample 1	0.200	0.400	0.300	0.900	0.600	0.917	4.000	0.447
Sample 2	1.800	1.166	1.800	1.249	2.000	1.095	3.300	0.458
Sample 3	3.000	1.000	3.100	1.221	3.000	1.414	1.900	0.700

SD = standard deviation

Using Bartlett's sphericity test, correlations between these three samples of soy-added hamburger in different percentages (25% for Sample 1, 50% for Sample 2 and 75% for Sample 3), in terms of the intensity of soy taste, odour or flavour, are significant, at the level of significance Alpha=0.050.

Significant values of correlation at the level of significance alpha=0.050 (two-tailed test) was obtained for the sensory parameters studied, as follows: a stronger correlation between taste (r=0.857) and odor (r=0.866) of the samples 2 and 3 respectively, between flavor of the samples 2 and 3 (r=0.904) and that of the samples 1 and 2 (r=0.896).

Also, texture is well correlated to the samples 2 and 3 (r=0.717) and the samples 1 and 3 (r=0.639).

In the second part of the testing sessions, a check-all-that-apply CATA question [25] consists of a list of 25 attributes which justify the influence of adding soy protein in ground beef of hamburger. Assessors selected all attributes they consider appropriate to describe the three samples of soy-added hamburger. For each category consumers were asked to check the number 1, if the sensory characteristic attribute was present and the number 0 if this attribute was not present.

Figure 2 presents the taste characteristics checked (*oily, metallic, raw, prick, frying*), the ones that were preferred over by the assessors after the sensory examination session.

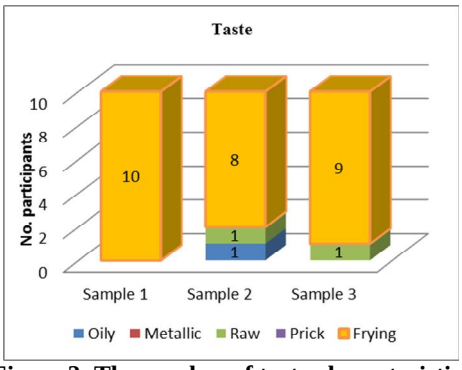

Figure 2. The number of taste characteristics chosen in CATA method

We noticed that the adjective "*frying*" is the most used in all three taste samples, in a percentage of 100% for the sample 1, 80% for the sample 2 and of 90% for the sample 3 respectively.

Figure 3 is presents the odor characteristics checked (*fried, soy milk, rancid, caramel, bean*), the ones that were preferred by the assessors after the sensory examination session.

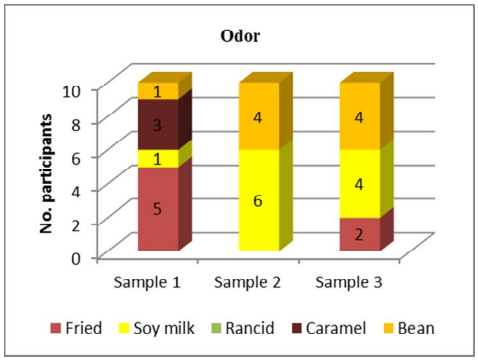

Figure 3. The number of odor characteristics chosen in CATA method

We noticed that the adjective "*fried*" is the most used in the sample 1, "*soy milk*" odor is the most used in the sample 2 and, in the sample 3 the most used adjectives are "*soy milk*" odor and "*bean*" odor respectively (equally distributed on a percentage of 40%).

Figure 4 presents flavor characteristics checked (*cereals, dried, boiled, cooked on the grill, off- flavour*), the ones that were preferred over by the assessors after the sensory examination session.

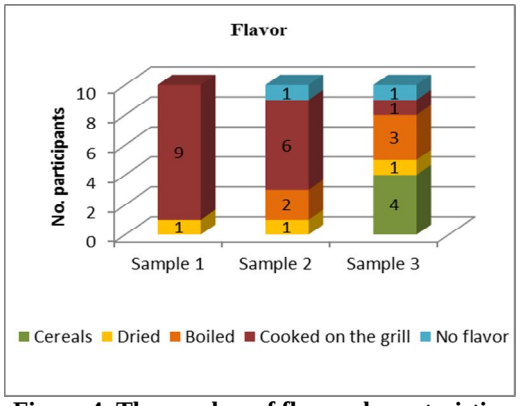

Figure 4. The number of flavor characteristics chosen in CATA method

We noticed that the expression "*cooked on the grill*" flavor is the most used in the sample 1 (in a percentage of 90%) and also in sample 2 (in a percentage of 60%), in the sample 3 the most used adjectives are "*cereals*" flavor (in a

percentage of 40%) and "boiled" respectively (in a percentage of 30%).

Figure 5 presents the texture characteristics checked (*soft, hard, elastic, wet*, and *dry*) the ones that were preferred over by the assessors after the sensory examination session.

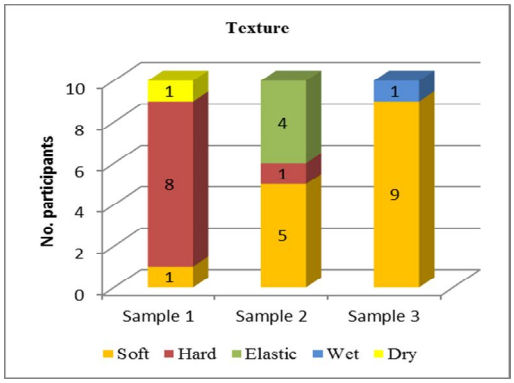

Figure 5. The number of texture characteristics chosen in CATA method

We noticed that the adjective "*strong*" texture is the most used in sample 1 (in a percentage of 80%), in sample 2 the most used adjectives are "*soft*" texture (in a percentage of 50%) and "*elastic*" texture respectively (in a percentage of 40%), and in sample 3 the adjective "*soft*" texture is the most used one (in a percentage of 90%).

Figure 6 presents the appearance characteristics checked (*fresh, appearance densely, homogeneous composition, crunchy, crumbly*), the ones that were preferred over by the assessors after the sensory examination session.

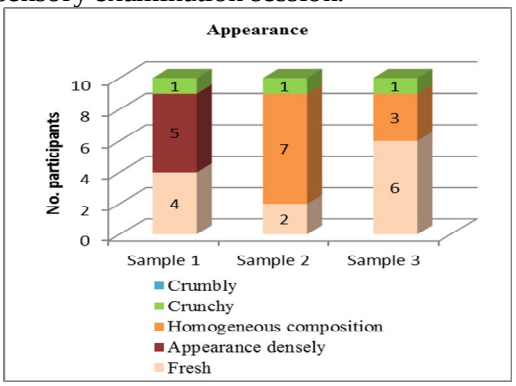

Figure 6. The number of appearance characteristics chosen in CATA method

We noticed that in sample 1, the most used expressions for appearance are "*appearance densely*" (in a percentage of 50%) and the adjective "*fresh*" respectively (in a percentage of 40%), the expression "*homogeneous composition*" is the most used in sample 2 (in a percentage of 70%), while in sample 3, the adjective "*fresh*" is the most used one (in a percentage of 60%).

The biplot graphics [26] based on principal component analysis (PCA) for the most important factors (F1 and F2), resulted from the above studied sensory characteristics are given in figures 7 - 11.

Figure 7 shows the biplot graphic for the taste characteristics chosen in CATA method, making obvious the fact that all the three samples tested are very similar regarding their taste characteristics.

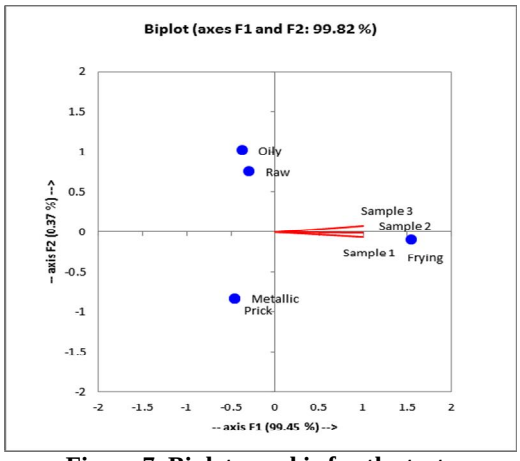

Figure 7. Biplot graphic for the taste characteristics chosen in CATA method

The variation of the parameters studied implies the existence of 3 factors. F1 (2.984) is the principal component which registers an eigenvalue higher than 1. The percentage of variability represented by the first two factors is high (99.82 %). The first factor (F1) explains 99.45 % of the total variance with a significant parameter "frying" with an important contribution of 79.53%, for the observations for the factor F1.

Figure 8 shows the biplot graphic for the odor characteristics chosen in CATA method, making obvious the fact that samples 2 and 3 are very similar in the odor characteristics, but they are different in sample 1. F1 (2.042) is the principal component that registers an eigenvalue higher than 1. The percentage of variability represented by the first two factors is high (98.09 %).

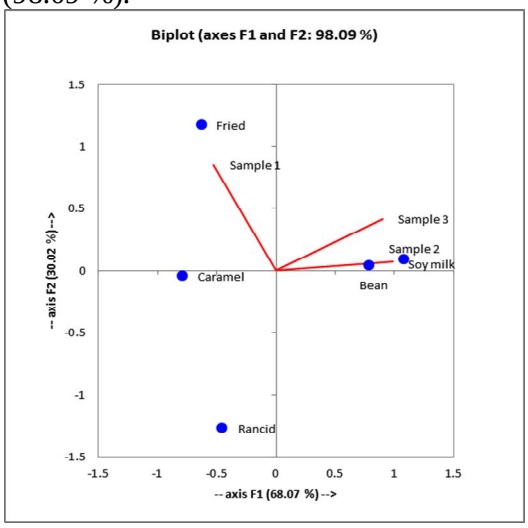

Figure 8. Biplot graphic for the odor characteristics chosen in CATA method

The first factor (F1) explains 68.07 % of the total variance with significant parameters "*soy milk*" and "*bean*" odor, having important contributions of 38.89% and of 20.57% respectively for the observations made for the factor F1. The second factor (F2) explains 30.02% of the total variance with a significant parameter "*fried*" having a contribution of 46.06% for the observations made for the factor F2.

Figure 9 presents the biplot graphic for the flavor characteristics chosen in CATA method, making obvious the fact samples 1 and 2 are very similar in the flavor characteristics, but they are different in sample 3. F1 (2.268) is the principal component that registers an eigenvalue higher than 1. The percentage of variability represented by the first two factors is high (98.26 %).

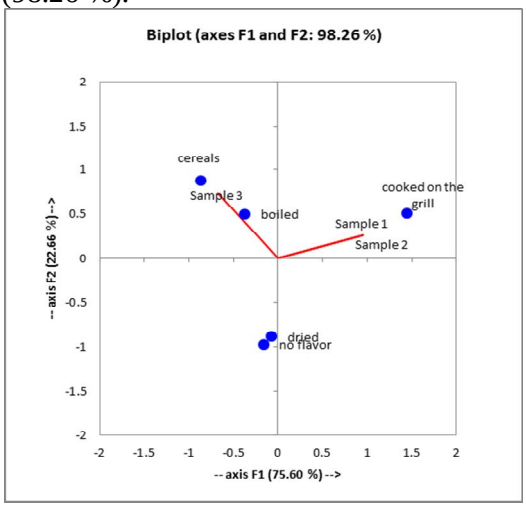

Figure 9. Biplot graphic for the flavor characteristics chosen in CATA method

The first factor (F1) explains 75.60 % of the total variance with the significant parameter "*cooked on the grill*" flavor, having important contributions of 69.91% for the observations for the factor F1. The second factor (F2) explains 22.66% of the total variance with significant parameters "cereal" and "*boiled*" flavour, having contributions of 25.47% and 8.1% respectively for the observations for the factor F2.

Figure 10 shows the biplot graphic for the texture characteristics chosen in CATA method, making obvious the fact that samples 2 and 3 are very similar in the texture characteristics, but they are different in sample 1. F1 (1.792) is the principal component that registers an eigenvalue higher than 1.

The percentage of variability represented by the first two factors is high (89.24 %). The first factor (F1) explains 59.72 % of the total variance with the significant parameter "*soft*" texture, having important contributions of 62.97% for the observations for the factor F1. The second factor (F2) explains 29.52% of the total variance with a significant parameter

"*strong*", having the contributions of 56.71% for the factor F2.

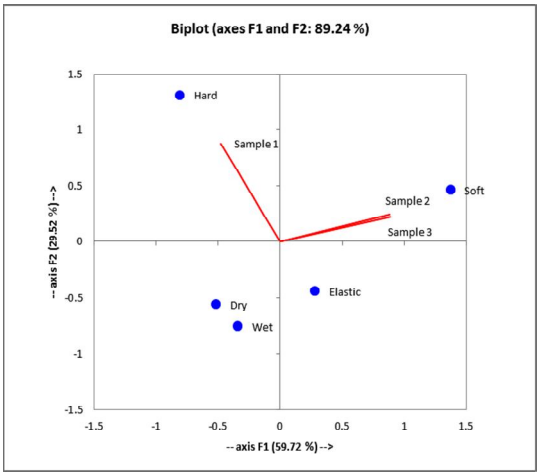

Figure 10. Biplot graphic for the texture characteristics chosen in CATA method

Figure 11 shows the biplot graphic for the appearance characteristics chosen in CATA method, making obvious the fact that all samples are different in the appearance characteristics.

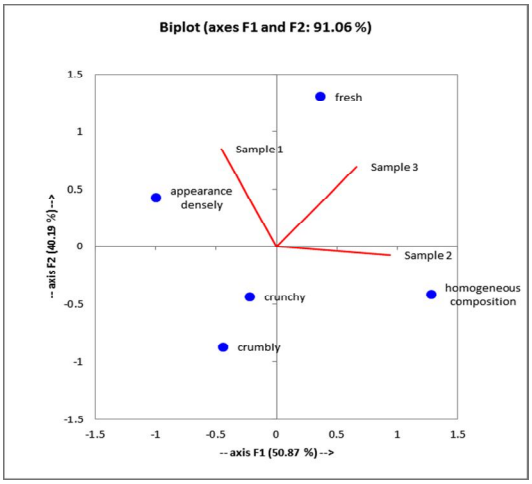

Figure 11. Biplot graphic for the appearance characteristics chosen in CATA method

F1 (1.526) and F2 (1.206) are the principal components that register higher eigenvalues than 1. The percentage of variability represented by the first two factors is high (91.06 %). The first factor (F1) explains 50.87% of the total variance with the significant parameter "*homogeneous composition*" appearance, having important contributions of 54.78% for the observations for the factor F1. The second factor (F2) explains 40.19% of the total variance with a significant parameter "*fresh*", having contributions of 56.37% for the factor F2.

4. Conclusions

Hamburgers are intensively consumed food products, especially by young people. The results obtained using free listing method consist of a list of terms describing taste characteristics (*oily, metallic, raw, prick, frying*), odor characteristics (*fried, soy milk, rancid, caramel, bean*), flavor characteristics (*cereals, dried, boiled, cooked on the grill, off- flavour*), texture characteristics (*soft, hard, elastic, wet, dry*) and appearance characteristics respectively (*fresh, appearance densely, homogeneous composition, crunchy, crumbly*) of soy-added beef hamburger.

Our study was made on three samples of soy-added beef hamburger in different percentages (25%, 50% and 75% soybean of total mass) and its aim was to analyze the effect of soy addition in beef hamburger on sensory properties.

After the testing session, the following results were obtained: in sample 1 (hamburger with 25% soy added) the taste, smell and flavor of soy are indistinguishable and the hamburger texture was graded as crusty (hard); in the case of sample 2 (hamburger with 50% soy added) the taste, odor and flavor of soybean in hamburger has been described as low or very low, and the texture was chosen as medium (neither hard nor soft); for sample 3 (hamburger with 75% soy added), the taste, smell and flavor of soy were defined as being low and texture was chosen as soft.

After using the check-all-that-apply (CATA) question method, the influence of adding soy protein in ground beef hamburger is as follows: the adjective "frying" is the most used in all three samples taste; the adjective "fried" is the most used for the odor in sample 1, "soy milk" odor is the most used in sample 2 and, whereas in sample 3, the most used adjectives are "soy milk" odor and "bean" odor respectively; the expression "cooked on the grill" flavor is the most used in samples 1 and 2, while in sample 3, the most used adjectives are "cereals" flavor and "boiled" flavour respectively; the adjective "hard" texture is the most used in sample 1, in sample 2 the most used adjectives are "soft" and "elastic" texture respectively and in sample 3 the adjective "soft" texture is the most used one; in sample 1 the most used expressions for appearance are "appearance densely" and "fresh" respectively, the expression "homogeneous composition" is the most used in sample 2, and in sample 3 "fresh" is the most used adjective.

In conclusion, consumers expect that these meat products added with soy protein to taste, look and smell in the same way as the traditional hamburgers, prepared only with ground beef.

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