Sensory Analysis In Meat and Meat Products

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Abstract: - Sensory analysis is one of the most widely used methods of food analysis today. The first method applied in this regard is the triangle test, which was performed in Scandinavian countries in 1940, and new test methods emerged in the USA and other European countries in the future. In general, sensory analysis is a discipline based on the perception, measurement, and interpretation of food in taste, smell, sight, touch, and auditory senses. Meat is a very important foodstuff in human nutrition among foods of animal origin, both with its nutritional value and its unique taste, flavor and aroma. The basis quality of meat production is directly related to the slaughter and processing of properly bred butchery animals in hygienic environments. Sensory evaluation of meat is important in the acceptability of meat and meat products, and the characteristics of meat such as color, texture, softness, juiciness, flavor and aroma are evaluated. Today, many analysis methods are used in food quality control and objective and instrumental analyzes that can fully meet sensory evaluations are not available.

Key-words: - Sensory characteristics, sensory assesment, sensory test, panel, meat, meat products
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1 Introduction

Meat and meat products, which have an important place in human nutrition, are important foodstuffs with their unique taste, aroma and flavor as well as their nutritional properties. As the standard of living and development level of societies increases, there is an increase in the consumption of meat and meat products. Quality is the sum of the characteristics of a product (fresh meat, sausage salami, bacon, etc.) or service based on meeting the expected or desired needs and can vary from person to person and from society to society. The production of quality meat and meat products depends on the rearing of healthy and high-quality butchery animals, and it is of great importance to deliver pre-slaughter practices, slaughter and shredding in slaughterhouses with hygienic conditions, packaging in accordance with the technique and cold chain to the consumer. Situations such as obtaining meat from unhealthy/suspicious animals, not complying with hygiene and sanitation rules, storing under inappropriate conditions, or adding various drugs and chemicals deteriorate the quality of meat and adversely affect human health [1,2,3].

Sensory tests in meat and meat products start with the raw meat obtained after slaughter, followed by heat-treated meat after maturation, and finally, the analyzes made on the meat product come into play. The quality of fresh meat obtained from slaughtered animals is affected by many factors (animal genotype, age, sex, feeding practices, transportation conditions, slaughtering process, storage conditions, etc.). In the ripening phase that begins with cooling, many biochemical reactions that contribute to the formation of meat quality occur [4]. These reactions affect many properties of meat and meat products such as colour, tenderness, flavor and aroma, and juiciness [1,3].

2 Sensory Assessments

Sensory evaluation is a discipline that measures, analyzes and interprets the responses of the senses of optic, smell, taste, touch or auditory to

various properties of food. In addition to the many objective evaluation methods available in food quality control, sensory evaluation continues to be important. In this sense, sensory tests are used in developing an existing product, maintaining quality in daily production, developing a new product and marketing analysis-consumer panels. In sensory evaluation, the quickest but least mature form of individuals' reactions to a stimulus is "perception" and the concept of intuition is defined as "absolute threshold". For example, the lowest concentration at which a taste is felt is the absolute threshold for that taste. The type of response that develops after perception is "recognition". The more advanced response type than recognition is "discrimination". The most advanced type of response is “rating”.

In sensory evaluations, the property to be measured should be clearly defined. In addition, it is very important to determine the error sources that may occur in the test, to select the panelist and to evaluate the results. These tests can be done as laboratory panel (trained) and consumer panel (untrained). The training and procedures to be applied to the panelists have been put forward by many organizations (ISO, BSI, ASTM). In these procedures, taste, smell, texture and general appearance are emphasized, and after the necessary training are given on these subjects, testing is started on meat samples.

The environment where the panelists will test should be light up, the temperature and relative humidity (20-22 ºC and 60-70%) should be adjusted and it should be away from external stimuli. Panelists should ideally be located in separate booths and should be prevented from communicating with each other. In the cabins there should be the possibility of a sink or a glass of water at a drinkable temperature on the table. Panelists should be provided with oral cleaning before and after tasting. This removes the taste of the previous sample and prevents it from affecting the taste of the second sample [5,6].

The appearance, size, temperature, serving plates, cups, coding, order of presentation and instructions to be given are very important in the sensory tests. In tests, foods are generally evaluated as they are consumed. Sensory tests should ideally be performed between 10:30–11:00 in the morning and 15:30–16:00 in the afternoon [1,6]. The number of panelists to participate in the panel may vary depending on the purpose, and panel groups can be organized of only males, females only, or mixed groups of males and females. These panels are generally organized into a group of 3–10 people from trained panelists, a group of 8–25 from semi-trained panelists, or a group of 80–100 from untrained panelists [6].

3 Considerations in Meat Sample Preparation

- The sample must be taken to represent the whole mass with appropriate tools and equipment.
- All samples to be tested must be at the same temperature. In this case, sensory properties are best perceived based on normal consumption temperature.
- Very hot and very cold meat and meat products should not be taken into sensory evaluation. The too-hot or cold sample also affects consistency and flavor.
- Variables such as temperature, boiling time, and amount of water should be controlled in the preparation of meat samples to be evaluated. The standard method should be used in heat treatment and samples should be heat treated at the same time. For example, the meat samples to be tested should be cooked by boiling, grilling, or roasting (can be at different temperatures, for example, 65 ºC, 72.5 ºC, and 80 ºC), and elements such as spices or sauces should generally be eliminated.

- The cup in which the samples are presented must be identical in color, shape, and size, with the sample cup not capable of misleading the senses. Sample cups made of glass and porcelain are more suitable for meat samples.
- Meat samples should be presented as consumed.
- Equal amounts and sizes of meat samples should be given to each of the panelists, usually in the amount that can be felt as a mouthful.
- For the identification of the samples, a triple code number consisting of random letters or numbers could be used.
- Samples should be the same shape, their consistency, color, and appearance should not be different.
- Generally, the number of samples to be presented in a session should not be more than 4-8 [1,2,6].

4 Sensory Quality Characteristics in Meat Samples

4.1 Color

Color is the first feature that creates the visual quality of meat and its products and attracts the attention of the consumer. Although the red hue in different types of meat such as beef, sheep and goat may differ, the substance responsible for the meat color is myoglobin in the protein structure. For example, the ideal meat color for cattle is bright cherry red, while bright rose red color is preferred in mutton. Depending on the age of the animal, the amount of myoglobin and the red tone increase with the advancement of age. In addition, with slicing or mincing meat, water loss increases and the color may become partially darker.

The color of meat products such as sausage, salami and sausage is desired to be close to the color of meat, which is the raw material and species used in production [2,7,8,9].

4.2 Texture and Tenderness

Among other quality characteristics, texture and softness have a great impact on the eating quality of meat. For example, in addition to its color, flavor, and juiciness, it is not preferred by consumers if meat tenderness is not suitable. The tenderness of the meat is influenced by the animal's breed and genotype, age, diet, procedures applied before and after slaughter, intramuscular fat accumulation, muscle fiber count ratio, connective tissue ratio and the degree of water collection of muscle proteins.

The texture feature is evaluated separately in raw and cooked meat, but since the meat is generally consumed by cooking, the analyzes made in cooked meat have a more important place. For the sensory determination of tenderness, meat samples cooked by a certain method at a certain central temperature are used. The tenderness of the meat sample is defined as the force required to provide a certain deformation or penetration by compressing the meat sample in the mouth between the molars or between the tongue and palate [2,3,8,10].

4.3 Juiciness

The water-binding capacity is the ability of meat or meat products to incorporate water from the outside. It is understood as the water retention property of the meat against the force applied from the outside by the basic processes. The color, texture and tenderness of fresh meat and the juiciness of cooked meat depend on its water-binding capacity. The water in the cell exists in three different forms (bound water, retained water and free water), and the goal of many meat processors is to ensure that most of the retained water is retained in the meat. Factors affecting the water holding capacity are pre and post slaughter treatments, a net load of

myofibrillar proteins, treatments applied to meat, meat pH and rigor mortis. Sensory determination of juiciness in meat samples is done after the determination of tenderness. For this purpose, the meat sample is broken down with the teeth many times in the mouth and the feeling it leaves in the mouth is evaluated [2,3].

4.4 Aroma and Flavor

The meat of each animal species has its unique taste, smell and flavor. Fresh meat has a distinctive slightly sourish odor caused by lactic acid, while older animal meat has a sharper odor than younger ones. The aroma in meat and meat products; is formed by many compounds with volatile properties such as aldehydes, ketones, esters, benzol compounds, furans, and lactones. Fresh meat lacks flavor and odor and has a bloody, metallic, serum-like sweet and slightly salty taste and odor.

A meat-specific aroma is affected by the glycolysis occurring in the post-slaughter phase and by ambient conditions. The development of characteristic aroma develops due to the heat treatment applied to the meat, and in this case, reactions occur between some non-volatile compounds (such as amino acids, peptides, carbonic acids, and sugars) and volatile taste and odor substances occur due to these reactions. In addition, the breed of the animal, the ration and diet of the animal, the environmental conditions in which it was raised, and changes before and after slaughter (pre-slaughter stress and post-slaughter ripening, etc.) also affect the aroma [2,6].

Flavor in cooked meat is formed by water or oil-soluble components and volatile components present in the meat. Because the ingredients in different animal meats are similar and the meats are often cooked in the same way, the flavors of different species can be similar. However, the differences seen are due to the difference in the ratio of the components. For example, the differentiation of lipid fractions in beef and mutton in terms of number and variety leads to the emergence of characteristic aroma [2,6,11].

5 Sensory Analysis Methods in Meat and Meat Products

5.1 Difference Tests

In simple difference tests, the panelists are expected to answer that there is or is no difference in the samples. In the directional difference tests, it is determined in which sample a predetermined quality feature is more intense. Certainty is required in the implementation of these tests, in the responses of the panelists and in the evaluation of the results.

The panel leader is responsible for controlling the test technique and application details. In the tests, properties such as appearance, taste, texture, shape, size, color and temperature should be checked, and conditions should be provided equally. To eliminate the color difference in the meat samples taken from different parts of the carcass, the environment where the samples are presented should be lit up with a red light [1,6].

5.1.1 Paired Comparison Test

The paired comparison test is used to identify differences or preferences between two samples for a particular trait, such as whether the meat sample is tougher or tender. These differences are presented as simple and directional differences. In a directional comparison test, the typical question is “which of the two meat samples would you prefer?”.

The disadvantage of this test is that complete and precise homogeneity in the characteristics of the samples is required. For example, although 2 meat samples taken from both the right and left sides of the carcass were presented to the panelists in beef cooked with different methods,

it was determined that there were difficulties in the evaluation [1,6].

In a study conducted by a researcher that the application of lactic acid in broiler meats was evaluated. The chicken carcasses obtained after slaughter were kept in 1% lactic acid solution (pH:2.4, 15 ºC) for 15 seconds. In the study, the carcasses were then preserved for two days, after which the thigh and drumstick samples were removed and grilled for 30 minutes. Control and treated samples were presented as a pair to each panelist (12 assessors took part, 4 paired comparisons each) who were asked which sample they preferred. In this study, there were 26 responses in the control direction and 22 in the treated direction. The assumption is that using lactic acid as a decontaminant would not be detected by a trained panel [12].

5.1.2 Triangle Test

3 samples are presented to the panelist at the same time and the panelist is informed that 2 of the 3 samples are the same and 1 is different. The panelist is asked to select a sample that is different or to identify similar samples. Another application of the triangle test is to determine which sample contains more intensively the previously defined properties from the panelist. The degree of success in the application of this test in meat samples is not high. It is difficult to eliminate the differences in all the animals from which the samples were obtained [1,6].

Study by some researchers focused on male and female cattle and castrated some of the male animals. Four different cooking methods were applied to the *M.longissimus dorsi*, *M.supraspinatus*, M.gastrocnemiusand, *M.psoas major* muscle samples taken from the carcasses, such as roasting, casserole, mince and grilling, and the differences in the meat samples were tried to be revealed. The results showed that bull meat could be significantly distinguished from steer meat. In the study of the same researcher on twin lambs of Suffolk and Dorset Down breeds, it was requested to determine the meat of male and female animals in both breeds [13,14].

5.1.3 Duo-Trio Test

In this test, the panelists are first presented with a reference sample, then two different samples are presented, and they are asked to determine which of these samples is similar or different from the reference. For example, in a study investigating the effect of cooling in normal and brine, chicken breast and thigh meats were used. In this study, in which 20-25 panelists took part a double-triple test was applied, the samples were presented by cooking on the grill. The panelists were able to determine the difference in cooling in chicken breast and thigh meats, salt water and normal water [15].

5.1.4 ”A”-“Not A” Test

There are 2 types of stimulants in this test and the test is done to determine the differences that may arise from the processes applied in the production of meat and meat products. “A” in the test is considered as a reference and the reference sample is presented to the panelists, and who are asked to identify the characteristics of the sample (general appearance, smell, taste, etc.) and place them in their memory. After the reference is removed, the sample to be tested is presented and the evaluator is expected to answer "A" or not "A". For this purpose, 10-50 panelists are used and 10 repetitions can be done in a series. The chi-square test is used in the evaluation of test results [1,6].

5.2 Quality-Quantitative Tests

These are the tests that allow the evaluation of all the quality characteristics of the product. These tests indicate the difference between products as well as the degree of difference and appreciation.

5.2.1 Ranking Test

This test is based on the panelist's ranking of more than three samples in terms of desired characteristics. The test is mostly used in developing a new meat product or to distinguish low-quality samples from good ones. A maximum of 20 samples can be evaluated in this test, but it is generally recommended to work with 6 samples because this may cause a loss of attention in the panelists. In this test, samples can be listed according to their specific properties such as color, hardness, and flavor. There may be some variation in the rank test due to panelists. For this, panelists should be grouped according to a certain logic and they can be asked to re-evaluate [1,6].

5.2.2 Scoring Test

In this test, the differences between the products and the degree of differences can be determined. For this purpose, a numbered scale is used, definitions of different scores are given and a mathematical connection is established between the scores. Success in tests depends on the use of a scorecard to accurately reflect the quality factors of the samples (usually first the appearance, then the smell, and finally the ones evaluated in the mouth), the absence of a difference in the meaning of each score and, if possible, the examination of the scoring test results by chemical and physical analysis. In quality-related scoring (there are different systems developed by different researchers), the equivalents of the scores can be arranged as indicated in Table 1. There are scoring scales used by different researchers and in scoring, a scorecard must be defined that accurately reflects the quality. Scoring cards can be prepared for various characteristics such as color, odour, hardness and general acceptability. The scoring in Table 1 is an example designed to assess overall quality of meat [1].

In this test, the answers given by 15-20 panelists are averaged and the standard error is calculated. Statistical analysis of the results obtained from scoring tests can be performed using the method of analysis of variance [1,5,6]. For example, in a study, the effect of different marbling levels in beef meat on the acceptability of consumers was investigated. In the results, the beef flavor scores given by the panelists increased with increasing fat levels (2 to 26%), correspondingly increasing the overall acceptability. This study demonstrates the importance of flavor on meat flavor, independent of meat tenderness [16].

Table 1. Sample scoring

Perfect	9
Very good	8
Good	7
Below good, above medium	6
Medium	5
Below medium, above bad	4
Bad	3
Very bad	2
Extreme bad	1

In a study, it was aimed to evaluate the effect of genotype and supplementary feeding on the sensory scores of goat meat obtained from different domestic goat genotypes and prepared using different heat process. Two heating treatments were used in this study, boiling and frying. Meat tasting for each thermal treatment was done randomly by a consumer panel composed of a total of 82 students and staff from the University of Fort Hare. The meat from each thermal treatment was randomly presented to the tasting panel. Eight point descriptive scales were used to evaluate aroma intensity (1=extremely bland to 8=extremely intense), the initial impression of juiciness (1=extremely dry to 8=extremely juicy), first bite (1=extremely tough to 8=extremely tender), juiciness (1=extremely dry to 8=extremely juicy), muscle fiber and overall tenderness (1=extremely tough, to

8=extremely tender), amount of connective tissue (1=extremely abundant to 8=none), overall flavor intensity (1=extremely bland to 8=extremely intense) and a-typical flavor intensity (1=none to 8=extremely intense) [17].

In a study, the aim was to determine the influence of ripening level on odor, tenderness, softness, taste, flavor and overall acceptability of meat. As material in this experiment, the meat of lambs of "Svrljig- Pirot Pramenka" hybrids were used. Lambs were 5 months old at slaughtering. The meat was roasted in the oven at temperature of 170°C for 60 minutes. As method, the quantitative-descriptive analysis is used. The results showed that meat ripening level influence on the acceptability of lamb meat and on the expressiveness of some attributes that closer define the sensory properties of meat (intensity, odor, tenderness, softness, taste, and flavor) [18].

5.2.3 Flavor and Texture Profile Analyses

These are the tests performed by trained panelists that reveal the properties of the product in question in detail. In the flavor profile test, the elements that make up all the flavor in meat and meat products and the relationships between these elements are examined. In the flavor profile test, first of all, taste, smell and character traits that make up the whole flavor are determined and defined. Then, the order of perception of character traits is determined and the intensities of these factors are graded in a scale system. Finally, the flavor intensity is graded and the aftertaste impression and continuity are determined. Panelists can jointly or independently give a score by discussing the criteria for the product, and the scores are transferred to a graph [6].

In the texture profile analysis, the mechanical (hardness, stickiness, chewiness, etc.), geometric (particle size, shape and distribution), fat and moisture properties and densities of the meat or meat product are evaluated. At the initial stage, the product is taken into the mouth and compressed between the teeth and the characteristics perceived in the first bite are determined. During the chewing phase, the product in question is evaluated by chewing in the mouth at a standard rate. In the last stage, the perceived properties of the chewed product are evaluated until it is swallowed [2,6]. For example, quantitative descriptive analysis (=sensory profiling) was used to characterize traditional sausages produced in the Massif Central region in France. Sensory data were correlated with information regarding the production obtained from the producers via a questionnaire. Thus the relationship between recipe/manufacturing and resulting sensory properties of the final products was established. The discriminant analysis revealed it was possible to classify the sausages correctly into specific manufacturing practice groups based on the sensory data. Hence, this approach can be used for quality labeling such as the protected designation of origin/ protected geographical indication [19].

6 Scales Used in Sensory Tests

Category scales are often used to rate different meat characteristics such as texture, flavor, and juiciness. They have the advantage of being easy to use and covering most quality features as well as evaluating up to six samples in one session. Such scales are, for example, very useful in determining the eating characteristics of meat based on the nutritional practices of animals and are frequently used for sensory evaluations in animal product production. However, if an individual characteristic of a food is to be evaluated, this approach does not provide sufficient information. How many features to focus on in the scales and the scoring system to be applied are the subject of discussion [2,6].

In the sensory tests of meat and its products, category scales are applied successfully. In a study, focused on breed, feeding practices and maturation conditions conducted on pork. An 8-point scale was used in the test and it was found that a ripening time of 10 days allowed the formation of softer meat than a 1-day application. In addition, it was revealed that the aroma of pork was affected and the aroma increased after 10 days [20]. In one study, pork was treated with 3% and 5% polyphophosphate, an 8-point scale was used by 10 panelists, and tenderness, juiciness and aroma intensity were evaluated. In the results, while tenderness increased with high polyphosphate application, juiciness increased with 3% polyphosphate application, no increase was detected above this value, and pork flavor decreased with high polyphosphate application [21].

In a study conducted by some researchers, Xhosa, Nguni, Xhosa-Boer cross and Boer breed goats were used and the differences in genotype and feeding on sensory characteristics were determined in meat samples cooked with different methods (boiling and frying). In the study, panelists of different ages, genders and living in different regions took part and an 8-point evaluation scale was used to determine meat flavor, tenderness, juiciness and meat connective tissue ratio. In the research, it was revealed that cooking with different methods and feeding style affect sensory properties [22].

In another study conducted on lamb meat, Svrljig-Pirot Premenka hybrid lamb meat, which was slaughtered at 5 months of age and matured at different times, was roasted at 170 °C for 60 minutes, and using a 7-point scale, it became odor, soft, and crispy, taste, aroma and overall acceptability were evaluated. In the study, it was determined that the maturation period affected the sensory properties of lamb meat [23].

The scales are of 4 types and can be prepared as category, graphic, hedonic and face scales [Figure-1,2]. For example, for category scales, firmness and tenderness characteristics can be determined in meat samples [24]. An example of a scale developed by [25] is given below.

Extreme hard Extreme tender

1	2	3	4	5	6	7	8

Fig. 1- Example of scale developed for hardness-softness

Name: Code: Date:

Please tick the answer you feel about the product offered to you in the following statements.

- I like it very much
- I like
- I like it moderately
- I like it a little
- I did not like at all

Fig. 2- Example of hedonic scale

Hedonic scales are mostly used in consumer tests and if the scale intervals are equal, t-test or variance analysis is used, and if not, non-parametric statistical model is used. Face scales can be used in preference studies involving untrained panelists. In these scales, facial expressions are used to give expressions of dislike-less-like moderate-somewhat like and very like, and panelists are asked to mark their preferences [6]. When using hedonic scales, demographic and socio-economic criteria (eg. age, gender, household size, income, region of residence), product use and consumer attitudes should be taken into account. In general, the products to be tested are intended to appeal to consumers. As consumers' hedonic ratings vary greatly with the educational background of the panelists, a large number of examples are needed to obtain an effective result [26]. In a study, hedonic scala was used and assessed the effect of providing information on the consumers' sensory evaluation of three burgers: 100% beef, 100% plant-based and a hybrid (60% beef and 40% vegetables). A total of 99 UK consumers with balanced age and gender were recruited. Results

show that consumers are positive towards hybrid burgers, in terms of overall acceptability, purchase intent and subjective comments. These results are valuable and should inform future marketing, labelling and reformulation efforts of new hybrid meat product launches [27].

Result and Conclusion

Sensory characteristics are those that are determined by the human senses and cause the consumer to accept or reject a food. Sensory characteristics are important for consumers as well as food producers. There are several analytical and instrumental methods employed for food product assessment, including microbiological procedures, instrumental analyses of tenderness, springiness, color, taste, and other traits of the widely understood food quality. Thus, this objective measurements can be made for individual quality items, but the overall effects of food on the consumer cannot be measured by any objective analysis or instrument. Therefore, sensory evaluation based on direct impressions remains a reference method and an invaluable measurement tool in food quality assessment.

All the effects of foods on the consumer are made according to the results evaluated by the group of tasters with certain characteristics by sensory test. A high level of rigor, knowledge, experience, selection of the appropriate test method, preperation os sample, and panelists are important in this regard.

Sensory tests applied in meat and its products have an important place in terms of identification and are being applied as a preferred method in revealing meat quality day by day. Meat and meat products are at a higher level in terms of sensory quality criteria compared to other foods in terms of high aroma and flavor components. The organoleptic characteristisc such as color, texture, juiciness, flavor, taste and odor of meat and meat products are evaluated by sensory tests. Sensory analysis in meat and its products are carried out for purposes such as maintaining quality in daily production, developing a new product, comparison between meat samples, R&D studies, increasing the quality of existing products and increasing sales by determining consumer taste. In the light of these purposes, the type of meat samples to be tested, the preparation methods of the meat samples, the selection of the panelists, the preparation of the panel rooms, the selection of the test method to be applied and the evaluation of the results are important. The information from sensory analyzes will help to understand in a systematic and scientific way what is required to design meat products that consumers want. In addition, with the developments in computer technology, the collection and statistical analysis of the data obtained from sensory tests can be done more easily. In addition, there is a need to develop new technological tools such as electronic noses and to determine the relationships between sensory tests and experimental results with instrumental tools.

Increased nutritional awareness by consumers, especially in developing countries, has made quality a new driving force behind purchase decisions. Thus recently, both members of academia and industry have been exploring sensory science to develop potentially successful products in today's competitive marketplace.

When applied correctly, sensory analysis is a powerful tool because it provides measurements that no other tool can provide: a detailed description of how a food item is perceived by the human senses and/or how well that item is liked. It is, therefore, fundamental to think about the scope of any sensory test and to consider good sensory practice.

References:

[1] Nute, G,R. *Sensory analysis of meat.* http://www.enq.ufsc.br/disci/eqa5217/material_didatico/MEAT_PROCESSING/1539_ch09.pdf (accessed on 09.01.2013), 2002.

[2] Öztan, A. *Et bilimi ve teknolojisi*. TMMOB Gıda Müh. Odası Yayınları Kitaplar Serisi. Yayın No:1. Ankara, 2008.

[3] Lazstity, R. *Meat and meat products. Food Quality and Standarts*. Vol II, Macaristan. http://www.eolss.net/Sample-Chapters/C10/E5-08-04-01.pdf. (accessed on 09.01.2013), 2009.

[4] Liu, Y., Lyon, B, G., Windham, W, R., Realini, C.E., Pringle, T.D. and Duckett, S. Prediction of color, texture, and sensory characteristics of beef steaks by visible and nearinfrared reflectancespectroscopy. A feasibilitystudy. *Meat Science,* 65, 2003, pp. 1107–1115.

[5] Hashmi, İ. Sensory evaluation techniques. 18th Annual IAOM Conference (MEA District) Muscat-Oman, December 2007. http://www.iaom-mea.com/EduMat/Dec11/Session5/Tech10-AGF-IAOM-Muscat-07.pdf. (accessed on 09.01.2013).

[6] Altuğ Onoğur, T. and Elmacı, Y. *Gıdalarda duyusal değerlendirme*. 2. Baskı. Ege Unv. Agr. Fac. Food Eng. Dept. İzmir, Turkey, 2011.

[7] Gökalp, H. Y. *Genel et bilimi ve teknolojisi.* Ders Teksiri. Atatürk Ünv. Zir. Fak. Gıda Bil. ve Tek. Bölümü. Erzurum, 1984.

[8] Resurreccion, A. V. A. Sensoryaspects of consumer choices for meat and meat products. *Meat Science,* 66, 2003, pp.11–20.

[9] Dawson, P. L. Packaging. In R.S. Alan (Ed). *Poultry Meat Processing*. Florida. CRC Press. 2001.

[10] Gökalp, H. Y., Kaya, M., Tülek, Y. and Zorba, Ö. *Et ve ürünlerinde kalite kontrolü ve laboratuvar uygulama kılavuzu*. 2. Baskı. Atatürk Ün. Zir. Fak. Yayınları. Yayın No: 318, Erzurum, 1995.

[11] Kerth, C. R., Miller, M. F. and Ramsey, C. B. Improvement of beef tenderness and quality traits with calcium chloride injection in beef loins 48 Hours Postmortem. *J. Anim. Sci.,* 73, 1995, pp. 750-756

[12] Van Der Marel, G. M., De Vrıes, A. W., Van Logtestıjn, J. G. and Mossel, D. A. Effect of lactic acid treatment during processing on the sensory quality and lactic acid content of fresh broiler chickens. *International Journal of FoodScienceandTechnology*, 24, 1989, pp. 11–16.

[13] Dransfıeld, E., Nute, G. R. and Francombe, M. A. Comparison of eating quality of Bulland steer beef. *AnimalProduction,* 39, 1984, pp. 37–50.

[14] Dransfield, E., Nute, G. R., Hogg, B. W. and Walters, B. R. Carcass and eating quality of ram, castrated ram and ewe lambs. *AnimalProduction*, 50, 1990, pp. 291–299.

[15] Janky, D. M. and Salman, H. K. Influence of chill packaging and brine chilling on physical and sensory characteristics of broiler meat. *PoultryScience*, 65, 1986, pp. 1934–1938.

[16] Corbin, C. H., Quinn, T. G. O., Garmyn, A. J., Legako, J. F., Hunt, M. R. and Dinh, T. T. N. Sensory evaluation of tender beef strip loin steaks of varying marbling levels and quality treatments *Meat Sci.,* 100, 2015, pp. 24–31.

[17] Xazela, N. M., Chimonyo, M., Muchenje, V. and Marume, U. Consumer sensory evaluation of meat from South African goat genotypes fed on a dietary supplement. *African Journal of Biotechnology*, Vol. 10(21), 2011, pp. 4436-4443. DOI: 10.5897/AJB10.1604.

[18] Inanovic, S., Savic, S., Baltic, M., Teodrovic, V. and Zujovic, M, Dependence of Lamb sensory properties on meat ripening level. *Biotechnology in Animal Husbandry*, 24 (3-4), 2008, pp. 93-100.

[19] Rason, J., Dufour, E. and Lebecque, A. Diversity of the sensory characteristics of traditional dry sausages from the centre of France: Relation with regional manufacturing

practice *Food Qual. Prefer.*, 18, 2008, pp. 517–30.

[20] Wood, J. D., Brown, S. N., Nute, G. R., Whıttıngton, F. M., Perry, A. M., Johnson, S. P. and Enser, M. Effects of breed, feed level and conditioning time on the tenderness of pork. *MeatScience*, 1/2, 1996, pp. 105–112.

[21] Sheard, P. R., Nute, G. R., Rıchardson, R. I., Perry, A. M. and Taylor, A. A. Injection of water and polyphosphate into pork to improve juiciness and tenderness after cooking. *MeatScience*, 51, 1999, pp. 371–376.

[22] Xazela, N. M., Chimonyo, M., Muchenje, V. and Marume, U. Consumer sensorybevaluation of meatbfrom South African goat genotypes fed on a dietarysupplement. *African Journal of Biotechnology*, Vol. 10(21), 2011, pp. 4436-4443.

[23] Ivanović, S., Savić, S., Baltić, M., Teodorović, V. and Žujović, M. Dependence of lamb sensory properties on meat ripening level. *Biotechnology in AnimalHusbandry,* 24 (3-4), 2008, pp. 93-100.

[24] Land, D. G. and Shepherd, R. *Sensory analysis of foods.* J.R. Piggott (Editör). Elseiver Applied Science, London, 155-185, 1988.

[25] Amerine, M. A., Pangborne, R. M. and Roessier, E. B. *Principles of sensory evaluation of food*. AcademicPress., New York, 602s. 1965.

[26] Mörlein, D. Sensory evaluation of meat and meat products: fundamentals and applications. The 60th International Meat Industry Conference MEATCON 2019. IOP Conf. Series: Earth and Environmental Science, 2019. doi:10.1088/1755-1315/333/1/012007

[27] Grasso, S., Rondoni, A., Bari, R., Smith, R. and Mansilla, N. Effect of information on consumers' sensory evaluation of beef, plant-based and hybrid beef burgers. *Food Quality and Preference*, 96, 2022, doi.org/10.1016/j.foodqual.2021.104417.