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Influence of the marinade and of the thermal treatment on the physical-chemical characteristics of deer meat

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Abstract

This research studies the influence of the marinade composition and of the vacuum heat treatment (Sous Vide procedure) on the physical-chemical properties of six types of deer meat. Three types of marinades made up of ingredients with different properties have been prepared. The packets of marinated meat vacuumed and sealed were subjected to the Sous Vide technique (thermal treatment at 60 °C, for 4 hours). The characterization was performed both on crude and cooked marinated samples and consisted of colorimetric and textural analysis, determination of hardness, elasticity, pH and mass loss. The results showed that the M3 marinade containing pickled red beet juice, anise, cinnamon, cloves, ground ginger, junibahar, honey, colored pepper, chilli powder and salt, showed the more efficient improvement of the deer meat, best retained its elasticity and induced the lowest color change. Thus, the M3 marinade is a promising solution for deer meat in order to obtain an attractive culinary preparate.

Keywords: deer meat; marinade; Sous Vide; colorimetry; pH; elasticity.

1.Introduction

The most important factor that influences the human body is food. The interdependence between the two is close, being directly influenced by its biological quality [1]. Meat is an important source of energy in our daily diet. From a nutritional point of view, meat plays a vital role in providing high quality protein, vitamins and minerals [2]. The meat must generally be heat processed to be safe for consumption. In addition to killing food-organisms, heat treatment affects various components and structures of meat, thus affecting sensory qualities and meat digestion [3]. Deer meat has a different smell and taste depending on the species, sex and age. The connective, interfibrillar and interphascicular tissue is less developed and has a finer and more compact fiber. The dark red color of game meat, which is classified as black meat, is due to the content of myoglobin, the intensity of muscle activity and the amount of blood retained [1]. The chemical composition is different compared to the meat of the slaughter animals: the proteins reach 21-23% of the total mass, the fats are below 1.2%, have a higher content in salts and vitamins.

Deer meat is richer in iron than spinach [1]. All game species require maturation and marinade to make the meat tastier and tender. When the animal is old, especially if it is hunted for which age cannot be known, the meat must be marinated for a long time. The meat is often so strong that it can be inedible. Marination is often needed to change the smell and taste of wild meat [2].

Meat preservation is extremely important to prevent damage and growth of bacteria that can endanger human health. Some reasons for preserving meat are:

1. *Preservation of quality and taste*

By preserving the meat properly, the quality and taste of the meat can be maintained. Damage to the meat can lead to altered texture, aroma and appearance, making it unusable or unpleasant for consumption [2].

2. *Preventing the bacteria growth*

Cracked or exposed meat can become a suitable environment for the growth of dangerous bacteria, such as *Salmonella, E. coli or Listeria*.

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Proper preservation, by refrigeration, freezing or other methods, helps to slow the growth of bacteria and prevent food poisoning [2]. Damage to meat can lead to an increase in the number of pathogenic bacteria and the production of toxins, posing a risk to the health of consumers. By preservation, the multiplication of these microorganisms can be prevented or reduced and it can be ensured that the product remains safe for consumption [2].

3. Extension of the validity period

Meat is a perishable product and can deteriorate rapidly due to the activity of bacteria, fungi and other microorganisms. Meat preservation helps to extend its shelf life, allowing distribution and consumption in a longer period of time. By preservation, the shelf life of the meat may be extended so that it can be stored and used for a longer period of time. This can be useful for storing and distributing meat safely [2].

4. Reducing the risk of food loss

Damage to meat can lead to food waste and economic losses. Proper preservation can reduce the risk of throwing away expired or damaged meat. Meat preservation can reduce food waste and contribute to the efficiency of the food chain and food preservation is a particularly important requirement both in terms of ensuring their sanitation (destruction of bacteria pathogenic and different parasites) as well as economically by keeping food on the food circuit that are protected from physico-chemical damage, biochemical but especially microbiological [2]. Conservation can extend the period of time in which meat can be marketed and consumed, which reduces financial losses and helps manage stocks more efficiently [10]. Also, meat preservation allows to obtain a wide range of meat-based foods, such as dried meat, sausages, salamis, canned foods, etc. This diversity of products helps to meet the preferences and needs of different categories of consumers [10].

5. Ensuring availability

Meat preservation facilitates transport and distribution over longer distances, thus allowing consumers to have access to fresh meat even in remote geographical areas or in seasons where supply is more limited. Meat preservation can help ensure the availability of this essential food throughout the year. Through techniques such as freezing or canned preservation, quality meat may be stored for use during periods when fresh is not available [10].

It is important to note that each type of meat may require specific preservation methods, such as refrigeration, freezing, drying or preservation in salts [4]. The main advantages of the Sous Vide technique include nutrient storage, intense flavors, tender and juicy textures, as well as precise cooking control. Due to the constant and precise temperature, the food is cooked evenly over the entire surface, without the risk of over-cooking. Low temperature and long-term cooking helps keep nutrients and flavors in food, resulting in more juicy and tasty dishes. By precisely adjusting the temperature, you can get the desired degree of cooking in the meat, from rare to medium or well-made, without the risk of over-cooking [5].

Food scientists have been actively studying sous vide processing since the 1990s [6] and have mainly been interested in using sous vide cooking to extend the shelf-life of minimally processed foods—these efforts seem to have been successful since there have been no reports of sous vide food causing an outbreak in either the academic literature or outbreak databases. Chefs in some of the world's top restaurants have been using sous vide cooking since the 1970s but it was not until the mid-2000s that sous vide cooking became widely known [7]; the late-2000s and early-2010s have seen a huge increase in the use of sous vide cooking in restaurants and homes [10]

Tornberg et al. [8] discussed the behavior of various meat proteins when heated. Most sarcoplasmic proteins are aggregated between 40 and 60 ° C, but for some of them coagulation can be extended to 90 ° C. The structural changes of cooking in whole meat and crushed meat products are then discussed, as well as changes in the water retention and texture of the meat product to which it leads [8].

The aim of the study was to analyze the behavior of different meat proteins in heating. Structural changes in cooking in whole meat and minced meat products, as well as changes in water retention and the texture of the meat product to which it leads, are then analyzed.

2. Materials and methods

2.1. Procurement of meat samples

The meat samples were purchased from the deer farm in Olsztyn, northeastern Poland. The deers were either fed cow feed or food purchased from the forest. 6 samples were considered from 6 red deer (coded as 13, 14, 15, 16, 19, 20) males, except for sample 20 derived from a wild deer. Different types of marinades were used for each sample and for a series of samples we did not use any marinade (reference). Marinated codes were: M0 (without marinade), M1, M3, M4.

2.2. Preparation of marinades

The M1 marinade was prepared from the following ingredients: salt, garlic, basil, rosemary, marjoram, thyme, oregano, mustard, granular pepper, oil, ground black pepper, ground hot peppers. The following ingredients were used to prepare the M3 marinade: pickled red beet juice, anise, cinnamon, cloves, ground ginger, junibahar, honey, colored pepper, chilli powder and salt. The following ingredients were used to make M4 marinade: rapeseed oil, rose juice, chilli powder, salt, ground black pepper, honey, Asian oil (soy). The ingredients of the marinades were homogenized for 2-3 minutes with a blender. Tables 1-3 show the types and quantities of ingredients used for the marinades tested.

Each marinade was prepared in 1L-capacity glass vessels. The pieces of meat were inserted in plastic bags to which was added 65 g of marinade. And 24 hours were stored for refrigeration at 4°C.

Table 1. Ingredients for marinade M1

	mass (g)	**percent (%)**
salt	3,84	1,11
granulated garlic	6,22	1,79
basil	0,77	0,22
rosemary	0,78	0,22
marjoram	0,81	0,23
thyme	0,5	0,14
oregano	0,65	0,19
mustard	19,2	5,53
Ground colored pepper	3	0,85
oil	310,89	89,48
ground black peppers	0,3	0,09
ground hot peppers	0,5	0,14
Total weight	347,46	100

Table 2. Ingredients for marinade M3

	mass (g)	**percent (%)**
beet juice pickled	300	77,77
Anise	30,7	7,96
Cinnamon	1,33	0,34
Ienibahar	2,45	0,64
Cloves	0,89	0,23
ground ginger t	0,21	0,05
Honey	46,81	12,13
Ground colored pepper	1,22	0,32
Chilli	0,15	0,04
Salt	2,01	0,52
Total weight	385,77	100

Table 3. Ingredients for marinade M4

	mass (g)	percent (%)
rapeseed oil	100	21,95
rose juice	300	65,86
chilli	1,56	0,34
salt	3,35	0,74
Ground black pepper	0,75	0,16
honey	49,06	10,77
Asian oil (soy)	0,77	0,17
Total weight	455,49	100

2.3. *Sous Vide* treatment

With the help of the Henkenovak 1000 vacuum cleaner, I removed the oxygen and sealed the meat bags that I wrote down with a water resistant marker to differentiate the samples, after which I used the Sous Vide technique to prepare the meat. I placed the bags sealed with meat in the water tub of the PURA Julabo water bath after setting the constant temperature at 60°C. I let the meat cook for 4 hours with the lid on. Instead of stainless steel, PURA uses polycarbonate for side walls, which leads to better insulation properties, being less conductive and still equal in terms of cleanliness and hygiene. The surface of the enamel is as hard as glass, scratch-resistant and extremely durable. Provides optimal hygienic protection because bacteria and other microorganisms are unable to reproduce in the water bath. All water baths have an integrated drain valve, as well as an internal timer function and a USB data port.

2.4. Characterization of deer meat samples

2.4.1. Macroscopic image of samples

It was made with a camera with a resolution of 2532 x 1170 pixels to 460 pixels per inch.

2.4.2. Determination of pH

After 24 hours of marination, the pH was measured using the pH of the Schott handylab ph 11 meter with a BlueLine 31 Rx glass electrode. Each value was expressed as an average ± standard deviation of three replicates.

2.4.3. Determination of colorimetric parameters

Measurement of color parameters of meat samples (L, A*, B*) was determined 3 times for each sample both before and after cooking using a reflectance colorimeter (Minolta CR-400). L, A* B* are the chromatic coordinates in spectrocolorimetry that indicate the brightness, the inclination towards red-green, respectively the inclination towards blue-yellow. The color variation was expressed as an average value ± standard deviation of six random readings. The color of each sample resulting from the three color parameters was determined using the Colorizer program [Web 1].

2.4.4. Mass loss

When cooked, the meat loses its juices, so that the animal protein in its composition shrinks. Therefore, the rule for cooked meat is that it loses its original weight [9].

To determine the exact mass loss of the meat marinated by the deer, each sample was weighed before cooking the sous vide and after.

The loss of mass, expressed as a percentage of evidence, is given by the following formula.

$$ML(\%) = \frac{m_0 - m1}{m0} * 100 \quad (1)$$

Where: m_0 = initial mass of the sample taken, expressed in grams before cooking (g), m_1 = mass of the sample part after cooking (g).

2.4.5. Texture profile and cutting resistance measurements.

The TPA shear force indices of the samples were determined using a texture analyzer. Pieces of meat were analyzed for their textural properties using Texture Analyzer Zwick / Roell model Z010 (Zwick Roell Italia Srl, Genoa, Italy) equipped with a rectangular aluminum probe (5 cm × 4 cm).

TPA parameters included hardness (N) and elasticity. Each sample was compressed to 30% of its original height when placed between two parallel plates. The test conditions were: 0.01 N preload, 50 N cell load and a transverse head speed constant of 50 mm / min. The analyzed parameters were represented by hardness (N) and elasticity (cm). The recorded results were expressed as an average ± the standard deviation of three replicates obtained using one piece of each sample for each measurement.

3. Results and discussions

3.1. Macroscopic image of meat samples

Figure 1 shows the samples of marinated meat prepared by Sous Vide. The first horizontal row includes each meat sample treated with the M1 marinade. The meat is tender inside and slightly crispy on the surface. The color has shades of pink inside and shades of brown-gray on the surface. The second horizontal row includes meat samples treated with M3. The meat is tender inside, more shades of pink more penetrating than those of samples marinated with M1, and on the surface the texture is not dried, reddish due to the red beet juice of the marinade composition. The third horizontal row presents the meat samples marinated with M4. The color is the most open of all samples, gray on the outside, pale pink on the inside, and the texture is slightly wet. Horizontal row IV is the samples of meat without marinade. They have a fine, juicy texture, slightly damp, pink color, very close to meat samples marinated with M1. The samples have an appetizing, juicy and tender appearance inside, colored from pale pink to slightly reddish, in the case of the marinade to which they were subjected. The shape and surface of the samples is not uniform.

Figure 1. Macroscopic image of meat samples

3.2. pH of meat samples

The pH of marinated deer meat was assessed before and after heat treatment. The pH values of the marinated raw meat are presented in Table 4.

Table 4. pH values of raw marinated meat samples*

Sample code	M1		M3		M4		M0 – no marinade	
13	$5,36^{B\ A}$	0,01	$4,74^{E\ D}$	0,00	$4,95^{E\ C}$	0,02	$5,06^{D\ B}$	0,00
14	$5,10^{C\ B}$	0,02	$4,97^{B\ C}$	0,00	$5,13^{C\ B}$	0,01	$5,24^{B\ A}$	0,01
15	$5,29^{C\ A}$	0,02	$5,02^{B\ C}$	0,00	$5,23^{D\ B}$	0,01	$5,28^{A\ A}$	0,00
16	$5,26^{C\ A}$	0,02	$4,66^{F\ D}$	0,01	$5,02^{B\ C}$	0,02	$5,08^{D\ B}$	0,02
19	$5,46^{B\ A}$	0,01	$5,32^{A\ B}$	0,01	$5,37^{A\ B}$	0,01	$4,89^{E\ C}$	0,01
20	$5,05^{E\ C}$	0,01	$4,88^{H\ D}$	0,02	$5,11^{C\ B}$	0,01	$5,17^{C\ A}$	0,00

* Letters written in blue will be analyzed vertically (for the same marinade). Letters written in black will be analyzed horizontally (for the same sample). Different letters mean that the difference between values is statistically significant in proportion of more than 95%.

For the M1 marinade, significant differences are observed between the meat sample no. 20 and other meat samples, this being also influenced by the fact that sample 20 comes from a deer grown in the wild, and the other samples come from deer raised on a farm. No significant differences in pH are observed between meat samples 14, 15, 16. No significant differences in pH are observed between samples 13 and 19 either, instead significant differences are observed between samples 13, 19 and 14, 15, 16. The lowest pH is found in sample 20, and the highest in sample 13.

For the M3 marinade, significant differences in pH are observed between sample 20 and all other samples.
The same goes for sample 16, which has the lowest pH, with a significant difference from the other samples, whose pH is higher. There are no significant differences in pH between meat samples 14 and 15.

For the M4 marinade, significant differences in pH are observed between sample 13 and other samples. Sample 13 has the lowest pH value and sample 19 the highest. There were no significant differences in pH between samples 14 and 20.

For un-marinaded samples (M0), the lowest pH value is sample 19. Significant differences are observed, for example between samples: 13 and 14, 13 and 15, 13 and 19, 13 and 20, 14 and 15, 14 and 19, 14 and 20. The highest pH value for marinade M0 is found in sample 14.

For sample 13 there are significant differences in pH depending on each marinade. The highest pH is recorded in the M1 (5.34) and the lowest pH is recorded in the M3 (4.74) sample. PHs less than 7 indicate acidity.

For sample 14 significant differences vary depending on each pH marinated, for example, between the M1 marinated sample and the M3 marinated sample there were significant differences, but not between the samples marinated with M3 and M0. The highest pH is recorded in the sample M0 (5.24) and the lowest in the sample marinated with M3 (4.97).

For sample 15 there are significant differences in pH depending on each marinade. The highest pH is recorded in the sample marinated with M0 (5.37) and the lowest pH is recorded in the sample marinated with M3 (5.02).

For sample 16 there are significant differences in pH depending on each marinade. The highest pH is recorded in the M1 (5.26) and the lowest pH is recorded in the M3 (4.66) sample.

For sample 19 there are significant differences in pH depending on each marinade. Samples marinated with M3 and M4 have an approximately equal pH without significant differences between them. The highest pH is recorded in the M1 (5.46) marinade test

In the case of raw marinated meat it can be seen that the pH is influenced both by the marinade applied to the samples, the highest pH value being recorded for the M1 and M0 marinades, and the lowest for the M3 marinade, this being the most acidic. The pH values of the marinated meat prepared by Sous Vide are presented in Table 5.

Table 5. pH values of prepared marinated meat Sous Vide*

Sample code	M1		M3		M4		M0– no marinade	
13	$5,10^{C\ B}$	0,02	$4,50^{F\ C}$	0,03	$5,15^{E\ B}$	0,01	$5,45^{D\ E\ A}$	0,01
14	$4,72^{F\ C}$	0,01	$4,71^{D\ C}$	0,02	$5,10^{F\ B}$	0,01	$5,43^{E\ A}$	0,01
15	$4,85^{D\ C}$	0,02	$4,61^{E\ D}$	0,02	$5,35^{B\ B}$	0,00	$5,47^{D\ A}$	0,02
16	$4,79^{E\ C}$	0,01	$4,81^{C\ C}$	0,02	$5,32^{C\ B}$	0,01	$5,51^{C\ A}$	0,02
19	$5,29^{A\ C}$	0,01	$5,20^{A\ D}$	0,01	$5,40^{A\ B}$	0,01	$4,62^{A\ A}$	0,01
20	$5,23^{B\ B}$	0,02	$5,06^{B\ C}$	0,01	$5,24^{D\ B}$	0,01	$5,56^{B\ A}$	0,00

*Letters written in blue will be analyzed vertically (for the same marinade). Letters written in black will be analyzed horizontally (for the same sample). Different letters mean that the difference between values is statistically significant in proportion of more than 95%.

According to Table 5, for the M1 marinade, significant differences are observed between the meat sample no. 20 and other meat samples. Between meat samples 13, 14, 15, 16, 19, there are also significant differences in terms of pH. The lowest pH is found in sample 16, and the highest in sample 19.

For the M3 marinade, significant differences in pH are observed between all meat samples. Different values of the pH are recorded depending on each sample, the highest value being recorded for sample 19, and the lowest value for sample 15.

For the M4 marinade, significant differences in pH are observed between all meat samples. Sample 14 has the lowest pH value and sample 19 the highest.

For non-marinaded meat (M0), the lowest pH value is sample 19. The highest pH value for marinade M0 is found in sample 14.

Significant differences are observed, for example between samples: 13 and 14, 13 and 16, 13 and 19, 13 and 20, 14 and 15, 14 and 19, 14 and 20.

No senior differences are observed between samples 13 and 14. The highest pH value for marinade M0 is found in sample 20.

For sample 13 there are significant differences in pH depending on each marinade. The highest pH is recorded in the sample marinated with M0 (5.45) and the lowest pH is recorded in the sample marinated with M3 (4.53).

For sample 14 significant differences vary depending on each pH marinated, for example, between the M1 marinated sample and the M3 marinated sample there were significant differences, but not between the samples marinated with M1 and M4.

The highest pH is recorded in the sample marinated with M3 (5.24) and the lowest in the sample marinated with M3 (4.71).

For sample 15 there are significant differences in pH depending on each marinade. The highest pH is recorded in the sample marinated with M0 (5.37) and the lowest pH is recorded in the sample marinated with M3 (5.02).

For sample 16 there are significant differences in pH depending on each marinade. The highest pH is recorded in the M1 (5.26) and the lowest pH is recorded in the M3 (4.66) sample.

For sample 19 there are significant differences in pH depending on each marinade. Samples marinated with M3 and M4 have an approximately equal pH without significant differences between them. The highest pH is recorded in the M4 marinated sample (5.40) and the lowest ph is recorded in the M0 (4.62) sample.

For sample 20 there are significant differences in pH depending on each marinade. Samples marinated with M1 M3 and M0 have an approximately equal pH without significant differences between them. The highest pH is recorded in the sample marinated with M0 (5.56) and the lowest pH is recorded in the sample marinated with M3 (5.06).

In the case of raw marinated meat it can be seen that the pH is influenced both by the marinade applied to the samples, the highest pH value being recorded for the M1 and M0 marinades, and the lowest for the M3 marinade, this being the most acidic.

After the meat was prepared Sous Vide, the pH of the meat increased compared to that of raw meat in all samples and all marinades. Significant differences are observed between the pH of raw marinated meat and that of prepared Sous Vide marinated meat.

Crude meat marinade mainly improves flavor and improves the tenderness of cooked meat, but also affects overall positive or negative color and acceptance. Tenderness is especially important for increasing the value of muscles rich in connective tissue. In addition, marinade can increase safety by reducing bacterial development, especially pathogens [10-12].

Sharedeh et al. [13] marinated slices of beef that were incubated for 24 hours at 10 °C in both acid marinade solutions using various weak acids (acetic, citric, lactic), so that their pH reaches 6.5, 5.4 or 4.3, and their NaCl content 0.9% or 2%. Histological changes were evaluated by image analysis using two parameters: mean cross-sectional area of the fiber (FCSA, μm 2) and extracellular space ratio (ECS,% surface). Changes in lipids and proteins were evaluated by oxidation, hydrophobicity of protein surface and aggregation of proteins by particle size (particle size and shape). ANOVA showed that FCSA decreased linearly while ECS increased when pH decreased from 6.5 to 4.3 to a low or high NaCl salt content. The decrease in pH significantly increased TBARS and carbonyl groups, while the increase in NaCl levels had a significant protective effect on lipids. No marinating effects on free thiols were observed. Hydrophobicity and aggregation of protein surface increased significantly with pH decreasing, but were not affected by NaCl. The effect of these physico-chemical changes on the nutritional value of meat is discussed [13].

Gault's detailed review [14] examined microstructural changes that may explain the tenderness of aged meat tissues by acid marinade depending on the pH of the meat. The main conclusions were that: (i) above pH 4.3, the swelling / tightening behavior of the beef muscle tissue is dominated by swelling / tightening of the fibers, itself caused by expansion/reduction of constitutive myofilament networks and is similar for different types of muscle for pH in the range of 5.1 to 3.0, (ii) collagen swelling also occurs, below pH 4.3 and refers mainly to perimisium and (iii) in cooking, swollen muscle fibers maintain a high degree of swelling, which resists thermal contraction due to the thermal cause of collagen. sensitivity. Beef logging can also be improved by early injection (pre-rigor or 24 hours postmortem) weak acid in meat tissue [14].

In addition, citric acid and acetic acid were used to inhibit lipid oxidation due to their ability to chelate iron ions from muscle foods. However, the addition of acid to meat could also promote the release of iron ions from myoglobin and hemoglobin, as well as accelerate the oxidation of these blood binding proteins, which, consequently, accelerates lipid oxidation [13, 15, 16].

In addition, lowering the pH of the meat could reduce the nucleophyility of free amino groups in muscle proteins and thus, could reduce their reactivity with reducing sugars during the initial stage of the Maillard reaction [17, 18].

Many other studies have shown that the sensory quality of the meat, especially tenderness, can be improved by acidic marination of aged meat using various weak acids (acetic, citric, lactic, etc.).

Other authors considered alkaline marinade; this process increases the pH of the meat from its initial post-mortem final value, but not necessarily above pH 7. This can also promote tenderness due to the swelling of the fibers related to the water retention capacity in the tissue (WHC-Water Holding Capacity). When NaCl is not added, the lowest WHC is observed at pH 5.1, corresponding to the isoelectric point of the proteins, and is more pronounced as the pH of the meat is farther from this value [13]. When NaCl is added, the minimum in WHC corresponds to a lower pH. This is in favor of alkaline marinade which promotes pH increase (but not necessarily above neutrality). The most common ingredients in alkaline marinade are polyphosphates. These have been shown to be effective for beef [13].

3.3. Monitoring of colorimetric parameters

Table 6 presents the colorimetric values and the color of the samples of raw marinated meat tested. For meat samples marinated with M1, the chromatic coordinates in spectrocolometry are analyzed and significant differences are observed between samples. In terms of brightness, for each sample, it varies. The highest light contrast is noticeable between samples 19 and 13. Sample 19 has the lowest L value and the highest L value. In terms of the color inclination to red-green, for the M1 marinade no significant differences are observed between samples 14, 15, 16 and 20, instead it is observed between samples 13, 19 and the rest of the evidence. The highest value A * is tested 19, which means that it has the highest inclination towards red-yellow colors, and, the lowest value A *, has the sample 13, being also the only negative value between samples. (-0.57). In terms of the color inclination towards blue-yellow, for the M1 marinade no significant differences are observed between samples 14, 15 and 20, instead, significant differences are observed between samples 13, 16, 19 and the rest of the samples. The highest B* value is recorded for sample 13, and the lowest B* value is recorded for sample 15. As can be seen in the colored table according to the analyzed chromatic coordinates, for meat marinated with M1 colors are observed specific to the spices used. For sample 19, the specific reddish color of game meat is the most highlighted.

For raw meat samples marinated with M3, significant differences are observed between samples, but for samples marinated with M1, the differences are more pronounced.

In terms of brightness, there are no significant differences between samples, except for sample 19, which has the highest value L (34.66), while all other samples marinated with M3 have an average value of 26.55. The highest light contrast is noticeable between samples 19 and 20.

In terms of color inclination to red-green, no significant differences are observed for the M3 marinade between samples 13, 14, 15, 16 and 20, but significant differences are observed between these samples and sample 19. Sample 19 has the lowest A * value, and sample 13 has the highest A * value*.

In terms of the color inclination towards blue-yellow, negative values for the M3 marinade are recorded for most samples, with significant differences between them. It can be seen that at this time the 15th sample has the lowest value of B *, and the 19th sample the highest value B*. There are no significant differences between meat samples 13, 14, 19, 20. instead these differences are noticeable between threshold 15 and all other samples.

As can be seen in the colored table according to the analyzed chromatic coordinates, reddish colors predominate for meat marinated with M3, specific to spices used in marinade, such as beet juice.

For meat samples marinated with M4, the chromatic coordinates in spectrocolometry are analyzed and significant differences are observed between samples. In terms of brightness, for each sample, this varies and significant differences can be noted between samples 13, 14, 15 and 16. No significant differences are observed for L between samples 14 and 19, 15 and 20. The highest value for brightness is recorded for sample 13 and the lowest value for sample 16.

In terms of color inclination to red-green, for samples marinated with M4, significant differences are observed between samples 13, 14, 15, 16, 19 and 20. No significant differences are observed for samples 14 and 19. The lowest A * value was recorded for sample 19 and the lowest A * From the point of view of the color inclination towards blue-yellow, for the samples marinated with M4 there are significant differences between the samples.

Table 6. Colorimetric parameters values and color of raw marinated deer meat samples *

Sample code	M1			M3			M4			M0		
	L	A*	B*	L	A*	B*	L	A*	B*	L	A*	B*
13	$48,58^{A\,A} \pm 0.75$	$-0,57^{C\,D} \pm 0.75$	$48,59^{A\,A} \pm 0.19$	$27,13^{B\,D} \pm 0.04$	$18,53^{A\,A} \pm 0.04$	$-0,65^{A\,B} \pm 0.02$	$40,71^{A\,B} \pm 0.15$	$6,19^{D\,C} \pm 0.15$	$9,41^{A\,B} \pm 0.63$	$36,23^{B\,C} \pm 0.25$	$7,74^{C\,B} \pm 0.25$	$4,55^{A\,C} \pm 0.39$
14	$41,38^{C\,A} \pm 0,14$	$2,70^{B\,C} \pm 0,14$	$9,39^{C\,A} \pm 0,54$	$27,07^{B\,B} \pm 1,24$	$16,59^{A\,A} \pm 2,24$	$-0,01^{A\,B} \pm 1,18$	$39,00^{B\,A} \pm 0,36$	$7,50^{B\,B} \pm 0,36$	$7,91^{B\,A} \pm 1,00$	$39,35^{A\,A} \pm 0,09$	$8,16^{B\,C\,B} \pm 0,09$	$4,42^{A\,B} \pm 0,57$
15	$39,14^{D\,A} \pm 0,50$	$2,93^{B\,D} \pm 0,50$	$6,77^{C\,B} \pm 0,5$	$26,47^{B\,D} \pm 0,15$	$16,62^{A\,A} \pm 0,5$	$-2,54^{C\,C} \pm 0,46$	$34,60^{C\,C} \pm 0,10$	$7,74^{C\,C} \pm 0,10$	$4,06^{C\,B} \pm 0,05$	$36,52^{B\,B} \pm 0,09$	$9,76^{A\,B\,B} \pm 0,09$	$3,73^{A\,B\,B} \pm 0,09$
16	$44,26^{B\,A} \pm 1,35$	$2,04^{B\,C} \pm 1,35$	$14,42^{B\,A} \pm 1,34$	$25,81^{B\,C} \pm 0,28$	$18,25^{A\,A} \pm 0,28$	$-1,12^{B\,C\,C} \pm 0,17$	$26,59^{D\,C} \pm 0,15$	$16,62^{A\,A} \pm 0,15$	$-2,54^{E\,C} \pm 0,46$	$37,42^{B\,B} \pm 1,41$	$10,48^{A\,B} \pm 1,41$	$4,55^{A\,B} \pm 0,90$
19	$28,36^{E\,B} \pm 0,77$	$17,75^{A\,A} \pm 0,77$	$9,24^{D\,B} \pm 0,19$	$34,66^{A\,A} \pm 0,23$	$11,52^{B\,B} \pm 0,22$	$0,69^{A\,B} \pm 0,21$	$33,99^{C\,A} \pm 0,23$	$11,52^{B\,B} \pm 0,23$	$0,63^{D\,B} \pm 0,21$	$33,35^{E\,C\,A} \pm 0,64$	$9,62^{A\,B\,C} \pm 1,64$	$3,55^{B\,A} \pm 0,12$
20	$38,93^{D\,A} \pm 0,04$	$3,07^{B\,D} \pm 0,04$	$8,26^{C\,A} \pm 0,20$	$24,56^{B\,C} \pm 0,49$	$17,97^{A\,A} \pm 0,49$	$-0,61^{A\,B\,D} \pm 0,03$	$39,31^{B\,A} \pm 0,47$	$6,29^{D\,C} \pm 0,47$	$6,53^{B\,B} \pm 0,15$	$36,28^{B\,B} \pm 0,15$	$9,10^{A\,BC\,B} \pm 0,15$	$3,25^{B\,C} \pm 0,29$

* Letters written in blue will be analyzed vertically (for the same marinade). Letters written in black will be analyzed horizontally (for the same sample). Different letters mean that the difference between values is statistically significant in proportion of more than 95%.

Table 7. Colorimetric parameters values and color of marinated deer meat samples prepared Sous Vide*

Proba	M1			M3			M4			M0		
	L	A*	B*	L	A*	B*	L	A*	B*	L	A*	B*
13	48,03^{AA}± 0.42	2.40^{BC}± 0.42	2,40^{BA}± 1,29	40,14^{ABC} ± 0.15	9,67^{AA}± 0.15	9,67^{AA}± 0.18	41,86^{BB}± 0.6	6,19^{DC}± 0.6	4,86^{BB}± 0.98	44,91^{BB}± 1,09	4,37^{BB}± 1,09	4,87^{AC}± 0.51
14	47,88^{AA} ± 0,9	3,35^{ABC} ± 0,90	3,35^{ABC} ± 0,72	38,91^{BB} ± 1,44	10,79^{AA} ± 1,44	10,79^{AA} ± 0,84	38,22^{CB} ± 0,09	5,89^{BB} ± 0,09	5,89^{BB} ± 0,09	49,53^{AA} ± 0,62	2,24^{CC} ± 0,62	2,24^{CC} ± 1,33
15	46,10^{AA} ± 0.65	3,10^{BC} ± 0,65	3,10^{ABC} ± 1,58	31,39^{CC} ± 0,28	9,18^{AA} ± 0,28	9,18^{AA} ± 0,39	38,61^{CB} ± 0,34	5,78^{BB} ± 0,34	5,78^{BB} ± 0,27	36,81^{DB} ± 1,37	7,75^{AAB} ± 1,37	7,75^{AAB} ± 1,69
16	43,49^{BA} ± 0,42	3,61^{ABC} ± 0,42	3,61^{ABB} ± 0,08	41,81^{AB} ± 0,41	10^{AA} ± 0,41	10^{AA} ± 1,94	41,12^{BB} ± 0,43	4,89^{BB} ± 0,43	4,89^{BB} ± 1,05	43,45^{BCA} ± 0,5	4,92^{BB} ± 0,5	4,92^{BCB} ± 0,08
19	40,44^{CAB} ± 1,56	5,50^{AB} ± 1,56	5,93^{ABA} ± 0,68	37,77^{BB} ± 0,80	9,57^{AA} ± 0,80	7,93^{AAB} ± 0,48	42,25^{BA} ± 1,28	7,93^{AAB} ± 1,28	9,57^{AA} ± 0,21	41,32^{CAB} ± 0,22	5,93^{ABB} ± 0,22	5,50^{AC} ±1,30
20	42,27^{BCB} ± 0,53	1,91^{BD} ± 0,53	1,91^{BC} ± 1,12	39,73^{BD} ± 0,30	8,99^{AA} ± 0,30	8,99^{AA} ±0,59	41,25^{BC} ± 0,18	5,17^{BC} ± 0,18	5,17^{BB} ± 0,23	49,44^{AA} ± 0,41	7,68^{AB} ± 0,41	7,68^{AA} ±0,30

Letters written in blue will be analyzed vertically (for the same marinade). Letters written in black will be analyzed horizontally (for the same sample). Different letters mean that the difference between values is statistically significant in proportion of more than 95%.

The pair of samples between which no significant differences are observed is the pair consisting of samples 14 and 19. The lowest B * value was recorded for sample 13 and the lowest B * value was recorded for sample 16.

The values of the colorimetric parameters for the marinated meat prepared by Sous Vide are presented in Table 7.

For meat samples marinated with M1, the chromatic coordinates in spectrocolometry are analyzed and significant differences are observed between samples. In terms of brightness, for each sample, it varies. The highest light contrast is noticeable between samples 19 and 13. Sample 19 has the lowest L value and the highest L value, the sample 13, just as in the case of raw meat. No significant differences are observed between samples 13, 14, 15.

In terms of the color inclination to red-green, for the M1 marinade, significant differences are observed between samples 14, 15, and 20.The highest value A * is tested 19, which means that it has the highest inclination towards red-yellow colors, and, the lowest value A *, has the sample 20.

In terms of color inclination to blue-yellow, no significant differences are observed for the M1 marinade between samples 14, 15, 16 and 19, instead, significant differences are observed between samples 13, 20 and the rest of the samples. The highest B * value is recorded for sample 19, and the lowest B * value is recorded for sample 20.

As can be seen in the colored table according to the analyzed chromatic coordinates, for meat marinated with M1 colors are observed specific to the spices used. For sample 19 and 20 the darker color specific to game meat is the most highlighted. It is observed that the shades of meat samples are very similar to each other after cooking Sous-Vide, as opposed to the samples of meat marinated before cooking.

For meat samples marinated with M3, in terms of chromatic coordinates in spectrocolometry, significant differences are observed between samples.

In terms of brightness, there are significant differences between samples. The highest light contrast is noticeable between samples 13 and 15 (as in the case of raw marinated meat). There are no significant differences between samples 14, 19, 20.

In terms of color inclination to red-green, no significant differences are observed for the M3 marinade between samples 13, 14, 15, 16 and 20, but significant differences are observed between these samples and sample 19. Sample 20 has the lowest A* value, and sample 14 has the highest A* value.

In terms of the color inclination towards blue-yellow, for the M3 marinade there are no significant differences between the analyzed samples. It can be seen that this time the 19th sample has the lowest value of B*, and the 14th sample the highest value B*.

As can be seen in the colored table according to the analyzed chromatic coordinates, brown-reddish colors predominate for meat marinated with M3, specific to spices used in marinade, such as beet juice.

For meat samples marinated with M4, the chromatic coordinates in spectrocolometry are analyzed and significant differences are observed between samples. In terms of brightness, for each sample, this varies and significant differences can be noted between samples 13, 14, 15 and 16. No significant differences are observed for L between samples 14 and 20. The highest value for brightness is recorded for sample 20 and the lowest value for sample 15.

From the point of view of the color inclination to red-green, for samples marinated with M4, significant differences are observed between samples 13 and 14, 13 and 15, 13 and 20 . No significant differences are observed between samples 13 and 16. The highest A* value was recorded for sample 15 and the lowest A* value was recorded for sample 14.

For meat samples marinated with M0 (without marinated), in terms of chromatic coordinates in spectrocolometry, significant differences are observed between samples. Raw deer meat is darker than other types of meat such as chicken or beef, indicating that it is strongly vascularized.

In terms of brightness, significant differences are observed between samples, for example between samples 13 and 14, 13 and 15, 13 and 19, etc.

From the point of view of the color inclination towards blue-yellow, for the samples marinated with M4 there are significant differences between the samples. The pair of samples between which no significant differences are observed is the pair consisting of samples 13 and 16. The lowest B* value was recorded for sample 15 and the lowest B* value was recorded for sample 14.

After marinating and cooking Sous Vide you can see the obtaining of some gray shades for the most part. For samples marinated with M3, a brown shade is observed, different from samples marinated with M1, M4 or M0.

3.4. Weight loss

The values of the mass loss of the samples of marinated meat treated sous vide are illustrated in Figure 8.

For meat samples marinated with M1, the lowest water loss is observed for sample 19. For the rest of the samples, the water losses are approximately equal, considerable. For M3 marinated meat samples the highest water loss is recorded for sample 19 and the lowest for sample 13. Compared to samples marinated with M1, the mass losses are higher, and compared to unmarked samples (M0) the losses are lower. For meat samples marinated with M4, no large differences are observed in terms of water loss between them. The percentage of loss of mass is not less than 25, but not more than 28%. Compared to samples marinated with M3, approximately the same amount of mass losses is observed. Samples marinated with M1 have the lowest percentage of mass losses, and non-marinated samples (M0) have the highest percentage of mass losses. For marinated meat, approximately equal water losses are observed for all samples, the highest losses are recorded for sample 14 (approximately 30%), and the lowest for samples 13 and 16 (~20%). Water losses for unmarked samples are higher compared to losses recorded for samples marinated with M1.

A similar study investigated the influence of cooking methods on the quality of meat of Sous Vide cooking method and oven cooking were compared using commercial pieces known as bone and foot steak from Corriedale lambs. All meat samples were analyzed for muscle surface or cut size, final pH, color, water retention capacity, shear force, cooking losses [19]. It was showed that the cooking losses of lamb were lower in the Sous Vide cooking method for both pieces studied. Evaporation was higher in oven cooking which can affect the loss of water and the juicy of cooked lamb. For both pieces used in the current study, the tenderness of the meat was similar, regardless of the cooking method used. The color and tenderness of the meat were not influenced by the cooking method, as opposed to the cooking losses were influenced by the cooking method [19].

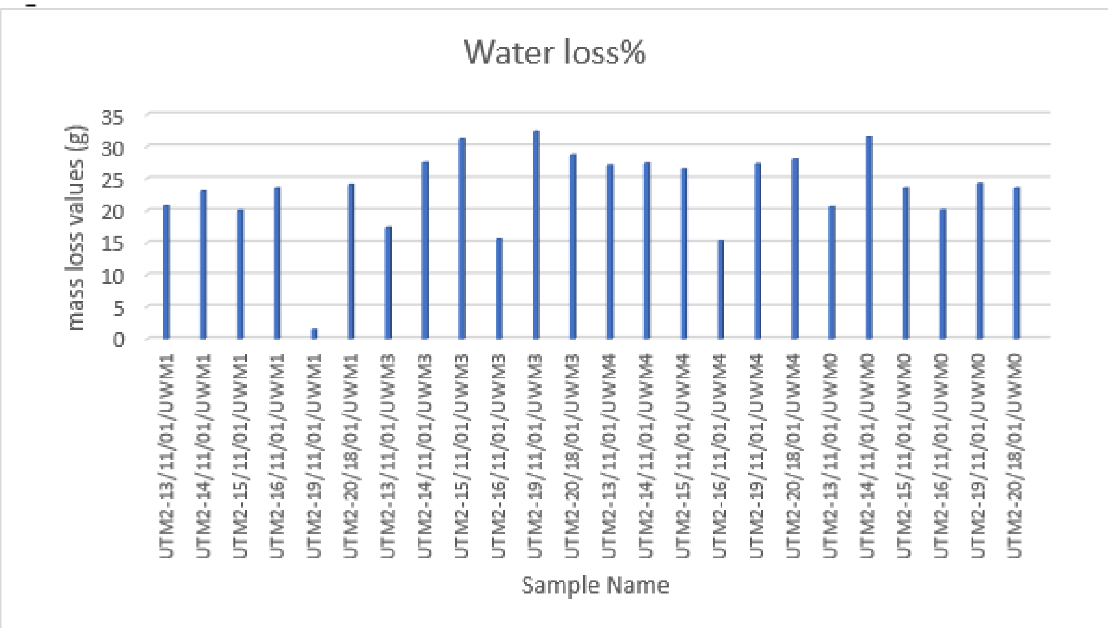

Figure 8. Mass loss for raw marinated meat cooked previously Sous Vide

Table 8. Hardness and elasticity of Sous Vide treated marinade meat samples

Sample	Hardness[N]	Elasticity [mm]
13 M0	15,43 ±1,12	24,57 ±1,73
13 M3	12,03 ±0,55	21,47 ±0,90
13 M4	46,07 ±2,37	20,80 ±0,14
13M1	21,07 ±1,59	19,83 ±0,25
14 M0	57,90 ±1,97	21,17 ±1,05
14 M3	6,63 ±0,36	22,77 ±1,51
14 M4	13,00 ±2,19	22,50 ±0,22
14M1	17,13 ±0,32	20,00 ±1,26
15 M0	19,10 ±1,25	24,30 ±0,88
15 M1	25,30 ±1,06	23,30 ±2,38
15 M3	13,47 ±0,91	21,30 ±0,22
15 M4	23,13 ±3,65	23,63 ±1,77
16 M0	17,88 ±3,10	22,97 ±1,73
16 M1	39,07 ±1,72	23,63 ±1,46
16 M3	25,27 ±1,15	25,17 ±1,19
16 M4	33,60 ±1,65	23,77 ±2,29
19 M0	14,43 ±1,44	24,90 ±,64
19 M1	36,83 ±2,72	22,13 ±3,54
19 M3	19,07 ±1,61	23,53 ±0,94
19 M4	28,33 ±0,76	23,93 ±1,89
20 M0	34,77 ±0,42	25,67 ±0,74
20 M1	40,27 ±0,84	23,93 ±2,08
20 M3	42,13 ±3,98	25,63 ±0,34
20 M4	23,83 ±1,21	24,63 ±0,49

3.5. Sample hardness and elasticity

Table 8 presents the values of hardness and elasticity of Sous Vide treated marinade meat samples. Deer meat is considered a tougher meat than beef or pork, but this can vary depending on several factors. In general, cooking sous vide meat can lead to a softer and juicier texture than traditional cooking, as heat is evenly distributed throughout the piece of meat. By analyzing the data in Table 8, it was observed that for meat samples 13, the highest value of the hardness was recorded for the sample marinated with M4 which has a significant difference from the rest of the values, from the samples marinated with M0, M1, M3. It is observed that the standard deviation of sample 13 M4 is quite high, which is due to the fact that the results are more dispersed than normal, which shows the presence of a possible error.

For meat samples denoted by 14, the highest hardness was the sample marinated with M0 (without marinated), with a significantly different value than the other samples. The lowest hardness was the sample marinated with M3, as in the fall of the sample 13. For samples 15, again, the lowest hardness is found in the sample marinated with M3, and the highest in the sample marinated with M1. In meat samples 16, the lowest hardness value is recorded for the M0 marinade sample, and the highest value for the M1 marinated sample. The meat sample marinated with M1 had the highest value of hardness among the meat samples which were marked with 19 and, the sample marinated with M0 (without marinated) had its lowest value.

From the meat samples that were marked with 20, the M3 marinated meat had the highest hardness, while the unmarinated meat had the lowest hardness.

A similar study investigated the effects of vacuum cooking (VC), traditional cooking (TC) and high pressure cooking (HPC) on the physico-chemical properties and texture of yak meat and on the digestibility of yak meat and intramuscular connective tissue (IMCT) [20]. They showed that traditional cooking at high temperature can cause excessive muscle fiber contraction, together with higher cooking losses and higher hardness [20], but Sous Vide processing can result in more uniformly cooked meat and can retain more water so that it has a higher rigidity [20]. They demonstrated that cooking methods had significant effects on the color, texture, oxidation of proteins and digestibility of yak meat. Yak meat treated with TC and HPC lost a lot of water, significantly decreased tenderness and increased protein oxidation than raw and cooked meat Sous Vide [20].

4.Conclusions

From the point of view of appearance, analyzing the macroscopic image of the samples of cooked meat Sous Vide shows that the most pleasant aspect belongs to the meat samples marinated with M3, with the most penetrating shades and the smoothest surface thus offering an aesthetic aspect to the product. At the same time, the M3 marinade gives the cooked meat sous vide the colorimetric results closest to those of the strongly vascularized deer meat of a reddish color, before cooking Sous Vide. In exchange unmarked samples, after cooking Sous Vide acquires a brown gray color, very close to the samples marinated with M4 and M1. In terms of taste, samples marinated with M1 cooked Sous Vide were the most appreciated. Unreported samples (M0) received the lowest score for sensory analysis, therefore the most undeniable taste, proving once again the importance of sailors in the process of cooking deer meat. From the point of view of texture, Sous Vide cooked meat samples have a low hardness, which keeps its tenderness for a long period, not becoming rigid . Of all the Sous Vide treated samples analyzed, the samples marinated with M4 have the highest hardness, with a significant difference from the samples marinated with M0, M1, M3, M4. The lowest hardness values between the samples analyzed are recorded for meat samples marinated with M1 and M3, except for meat sample 20 which comes from a wild deer, this influences the hardness of the meat. The elasticity of the meat is kept approximately constant for all the tests and all the times of the marinade.

With very little difference from the M1 marinade, the M3 marinade gave the best results in total in terms of texture, taste, had the lowest hardness, the color was closest to the unmarked fresh meat, the elasticity was preserved. In conclusion, both the M1 marinade and the M3 marinade are recommended for cooking deer meat. Sous Vide treatment has proven beneficial for the preparation of deer meat, giving it optimal hardness and elasticity, being an efficient process while contributing to the improvement of properties, ensuring consistent and uniform results.

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Compliance with Ethics Requirements. Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human / or animal subjects (if exist) respect the specific regulation and standards.

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