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Influence of vacuum packaging on quality of beef muscle after different tenderization methods

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Abstract

The quality of meat products is a major problem that currently concern all policy makers involved. Obtaining meat products able to attract an as large as possible number of consumers called for approaches to the scientific research in the meat industry. Since natural aging is a long-term process, artificial aging is recommended to \\be widely used in the meat industry and catering. Thus, in the present study were tested two methods of artificial tenderization of meat: enzymatic tenderization with proteolytic enzymes extracted from plants (papain from papaya and bromelain from pineapple) and chemical tenderization with $CaCl_2$ and NaCl. To increase storage period of the products obtained was applied conservation through vacuum packaging. The objective of this study was to investigate the effects of injection with 0.4 M sodium chloride, 0.2 M calcium chloride, 1 mg papain/100g, 1.5 mg papain/100g, 2 mg papain/100g, 1 mg bromelain/100g, 1.5 mg bromelain/100g, 2 mg bromelain/100g on adult beef at 24 hours post slaughter; the percentage of brine injected was 10%(v/w). After injecting, meat pieces were vacuum packed and stored at refrigeration temperature 40°C. In this experiment, the influence of thermal treatment applied to beef meats artificial tenderized was evaluated by monitoring storage losses, monitoring losses at thermal treatment (boiling and grilling), assessing changes in texture by determining the compressive strength and sensory analysis of the beef samples. During storage and artificial tenderization of the samples vacuum packed, were noted for all indicators followed variations indicating the proteolysis process development, which signifies an improvement in meat tenderness. Sensory analysis of the samples showed improving in meat tenderness with the reducing of meat juiciness due to large juice losses during storage and thermal treatment.

Keywords: meat quality, beef tenderization, proteolytic enzymes, calcium chloride, rigidity index

1. Introduction

Meat quality can be defined as a combination of diverse properties of fresh and processed meat. These properties contain both sensory characteristics and technological aspects, such as colour, water-holding capacity, cooking losses, and texture [1-5]. Of the sensory characteristics, eating quality, which consists of flavour, tenderness and juiciness, has been regarded as the most critical characteristics because it influences repeat purchases by consumers.

Consumers have identified tenderness as the most important beef sensory attribute [7,8]. Tenderness differs among bovine muscles from various anatomical locations largely because of differences in the structural components, which influence tenderness namely the myofibrillar and connective tissue proteins [9,10]. Therefore, there is considerable interest in developing strategies to improve palatability and hence add value to the beef meat. Marinating is an effective means of enhancing the quality of meats.

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Marinating is the process of soaking or injecting meat with a solution containing ingredients such as vinegar, lemon juice, wine, soy sauce, brine, essential oils, salts, tenderizers, herbs, spices and organic acids to flavour and tenderize meat products [11,16]. Beef is a highly perishable food commodity with a short shelf life. Among the factors affecting the shelf life of fresh meat, microbial growth and metabolic activities are by far the most important causes of spoilage which may be manifested as visible growth (slime, colonies), textural changes or off-odors and off-flavours [12-15]. Numerous types of food packaging in combination with different storage techniques can be used in order to extend the shelf-life of meat. One of the key technological measures needed during storage is the preservation of the meat from microbial spoilage and contamination/proliferation of pathogenic microorganisms. The objective of the present study was to investigate the influence of different methods of tenderization (enzymatic and chemical tenderization) on quality of beef meat vacuum packed stored at refrigerated temperature.

2. Materials and methods

The raw material, utilized in research program, was represented by the beef thigh from adult cows (more than 9 years old). The meat was purchased in hot state from a local slaughterhouse at maximum two hour post-slaughter. Salt was of food-suitable purity, being a largely used additive in meat industry, papain and bromelain were purchased from Lay Condiments, Bucharest (Papain Chilko P, Bromelin EC 3.4.4.24).

*Chemical analysis:*Weight losses at storage and thermal treatment were calculated as difference between samples weigh until and after thermal treatment, storage respectively. The sensorial analysis was according to the method described by the American Meat Science Association [6].

*Sample preparation:*The adult beef meat separated from conjunctive tissue and fat was cut into pieces of the same size in length and thickness (1, 5 – 2, 0 cm) weighing approximately 150 g, cut along the muscular fibers.

The meat pieces were then divided into nine groups and were used for a certain treatment. For each treatment series were constituted, consisting of:

- *Sample* P_1 – pieces of meat with not injected with 10% brine with papain addition to a concentration of 1 mg/100g meat;
- *Sample* P_2 – pieces of meat injected with 10% brine with papain addition to a concentration of 1,5 mg/100g meat;
- *Sample* P_3 – pieces of meat injected with 10% brine with papain addition to a concentration of 2 mg/100g meat;
- *Sample* P_4 – pieces of meat injected with 10% brine with bromelain addition to a concentration of 1 mg/100g meat;
- *Sample* P_5– pieces of meat injected with 10% brine with bromelain addition to a concentration of 1,5 mg/100g meat;
- *Sample* P_6 – pieces of meat injected with 10% brine with bromelain addition to a concentration of 2 mg/100g meat;
- *Sample* P_7 – pieces of meat injected with 10% $CaCl_2$ to a concentration of 0.2 M;
- *Sample* P_8 – pieces of meat injected with 10% NaCl to a concentration of 0.4 M;
- *Sample* P_9 (control sample) - pieces of meat no injected.

The injection was performed manually with a syringe, so that the entire brine quantity could be uniformly pumped into the whole muscular mass. The eliminated brine was reinjected. The injected meats were vacuum packaged and stored at $4^0C \pm 1^0C$ for 11 days. Vacuum packaging was performed using a vacuum packaging machines, VACSY System, produced by the company Zepter International Zepter using a package type, with the following characteristics: permeability to O_2 (at 23^0C and 0% RH) <30 cm^3/m^2•24h•atm and CO_2 permeability (at 23^0C and 0% RH) = 150-200 cm^3/m^2•24h•atm.

3. Results and Discussion

Assessing the influence of vacuum packaging on the technological characteristics of adult beef, artificial tenderized was achieved by: monitoring storage losses, monitoring losses from thermal treatment and sensory analysis of the samples studied.

The influence of artificial tenderization of beef meat on losses during storage in anaerobiosis conditions - Weight losses during storage were conditioned by the treatment of adult beef during storage at refrigerated temperature, 4^0C (Table 1).

Thus, increasing storage time from one day to 11 days and increasing the amount of enzyme used in the study has led to increased losses.

The highest value of losses was recorded by the samples injected with papain at the highest concentration taken in the works, 2 mg/100g meat, for a storage period of 11 days and the lowest value being recorded at one day of storage by the control samples.

The influence of artificial tenderization on losses during thermal treatment of the beef meat stored in anaerobiosis conditions - Cooked meats had suffered significant changes, one of the most important being weight loss caused by the juice and fat losses recorded (Table 2).

The changes that took place in artificial tenderized meats were dependent on the degree of hydrolysis of muscle proteins, because of the fragmentation, more or less pronounced, of the protein chains under the action of endogenous enzymes (control samples), endogenous and exogenous proteolytic enzyme (samples treated with papain / bromelain), endogenous enzymes and chemicals (samples treated with $CaCl_2$ / NaCl). Samples injected with $CaCl_2$ and NaCl recorded lower losses at thermal treatment compared with the samples injected with papain and bromelain but higher compared with the control samples. These results indicate that as the protein chains are increasingly fragmented take place greater water losses from tissues.

*Sensory characteristics assessment after cooking of beef meat vacuum packaged - Meat flavour:*During aging of the samples artificial tenderized and vacuum packed meat flavor has developed differently depending on treatment and storage time (Table 3).For all the samples increasing the storage period resulted in a decreasing trend of flavour. Lowest scores given to flavour had recorded by the samples injected with papain followed by samples injected with bromelain, $CaCl_2$, control samples and the samples injected with NaCl. The increase of enzyme concentration and storage period resulted in decreasing of flavour scores caused by the appearance of foreign beef taste sensation (taste of the liver).

Meat tenderness: Changes in scores given to tenderness sensorial characteristic at the adult beef samples chemical and enzymatic tenderized depending on ageing period are presented in Table 4. From the data presented in Table 4, it can be see that beef tenderness, assessed by mastication, was influenced by storage time and tenderization method. Beef tenderness in the samples injected with bromelain, calcium chloride, sodium chloride and control samples was generally low compared with the samples injected with papain, the changes that took place in the myofibrillar system were not sufficiently intense to cause softening of muscle tissue, to give resulted a meat with high tenderness even after 11 days of storage at 4°C.

Adult beef meats injected with papain were registered for the characteristic tenderness the highest scores at 11 days of ageing at temperature of 4^0C at the highest concentration used in the study, papain 2 mg /100g meat. Increasing the level of added papain and duration of enzyme action cause a significant weakening of meat structure [17-24]. With the increasing of papain level and with the increasing of ageing time from 1 to 11 days, found an advanced fragmentation of muscle fibers, part of the enzyme treated meat becomes soft after cooking with very little resistance to mastication.

Meat juiciness: Juiciness of the meat was also affected by the type of tenderization used (chemical or enzymatic). From the analytical results it can be concluded that thermal treatment of the samples artificial tenderized caused a reduction of juiciness during the entire period of storage in anaerobiosis condition. The highest scores were given to the samples injected with NaCl followed by samples injected with $CaCl_2$, control sample, the samples injected with bromelain and to the samples injected with papain.

The causes of the reduction of juiciness is due to the higher losses suffered by the samples during storage and thermal treatment, losses that are induced by the physical-chemical, biochemical and histological changes occur during postmortem aging being intensified by the thermal treatment applied, too.

Table 1. The influence of artificial tenderization on losses during storage in anaerobiosis conditions

Time of ageing [days]	Losses during storage [%]								
	1 mg papain/ 100 g	1.5 mg papain/ 100 g	2 mg papain/ 100 g	1 mg bromelain / 100 g	1.5 mg bromelain / 100 g	2 mg bromelain / 100 g	0.2 M $CaCl_2$	0.4 M NaCl	Control sample
1	5,41	5,69	5,82	4,17	4,81	4,89	3,92	3,88	1,15
3	5,95	6,59	6,99	5,1	5,45	5,9	5,1	4,97	1,83
5	6,61	7,12	7,93	5,6	5,78	5,96	6,5	5,34	2,26
7	6,82	7,98	8,44	5,99	6,34	6,68	6,78	5,59	2,92
9	7,08	8,96	9,09	6,19	6,63	6,9	7,47	6,31	3,24
11	9,97	10,02	11,94	7,28	9,08	9,28	7,7	6,82	3,47

Table 2. The influence of artificial tenderization on losses during thermal treatment in anaerobiosis conditions

Time of ageing [days]	Losses during thermal treatment [%]								
	1 mg papain/ 100 g	1.5 mg papain/ 100 g	2 mg papain/ 100 g	1 mg bromelain / 100 g	1.5 mg bromelain / 100 g	2 mg bromelain / 100 g	0.2 M $CaCl_2$	0.4 M NaCl	Control sample
1	5,02	5,97	6,21	5,35	5,24	5,69	5,16	5,39	3,85
3	5,26	6,33	6,26	5,37	5,44	5,62	5,68	5,52	4,29
5	5,36	6,07	6,34	5,47	5,57	5,78	5,7	5,53	4,38
7	6,2	6,37	7,48	5,79	6,42	6,58	6,23	5,86	4,56
9	6,46	7,64	8,29	6,22	7,28	7,6	7,54	6,98	5,35
11	7,8	8,01	8,73	7,3	7,49	8,77	7,92	7,71	6,2

Table 3. Score variation accorded to meat flavour depending on treatment applied and ageing time

Time of ageing [days]	Meat flavour								
	1 mg papain/ 100 g	1.5 mg papain/ 100 g	2 mg papain/ 100 g	1 mg bromelain/ 100 g	1.5 mg bromelain/ 100 g	2 mg bromelain/ 100 g	0.2 M $CaCl_2$	0.4 M NaCl	Control sample
1	4,08	3,92	3,85	4,5	4,71	4,14	4,54	4,75	4,14
3	3,29	3,21	3,15	3,57	3,57	3,23	4,42	4,57	3,57
5	3,14	3,14	2,88	3,85	3,28	3,14	3,71	4	3,57
7	3,02	3	2,28	3,57	3,14	3	3,71	3,88	3,42
9	2,43	2,25	2,1	2,66	3,06	2,33	3,33	3,63	3,66
11	1,2	1,2	1,2	2,12	2,09	2,02	2,2	3,2	3,2

Table 4. Score variation accorded to meat tenderness depending on treatment applied and ageing time

Time of ageing [days]	Meat tenderness								
	1 mg papain/ 100 g	1.5 mg papain/ 100 g	2 mg papain/ 100 g	1 mg bromelain / 100 g	1.5 mg bromelain / 100 g	2 mg bromelain / 100 g	0.2 M $CaCl_2$	0.4 M NaCl	Control sample
1	6,8	7	7,15	5	5,14	5,42	5,14	5	3,42
3	7,14	7,2	7,29	5,42	5,57	5,71	5,17	5,08	3,71
5	7,24	7,58	7,62	5,64	5,69	5,74	5,24	5,15	3,85
7	7,51	7,71	7,74	5,71	5,87	5,94	5,42	5,14	3,95
9	7,53	7,6	7,76	6,14	6,26	6,33	5,53	5,16	4,33
11	7,68	7,72	7,9	6,48	6,54	6,59	5,72	5,29	4,4

Table 5. Score variation accorded to meat tenderness depending on treatment applied and ageing time

Time of ageing [days]	Meat juiciness								
	1 mg papain/ 100 g	1.5 mg papain/ 100 g	2 mg papain/ 100 g	1 mg bromelain/ 100 g	1.5 mg bromelain/ 100 g	2 mg bromelain/ 100 g	0.2 M $CaCl_2$	0.4 M NaCl	Control sample
1	5,28	5	5	5,64	5,42	5	5,85	6,14	5,67
3	4,91	4,72	3,85	5,57	5,28	4,57	5,71	5,85	5,57
5	4,16	4,14	3,42	5,14	4,85	4,28	5	5,57	5,05
7	4,17	3,85	3,28	5	4,54	4,28	4,85	5,42	4,52
9	4	3,66	3,15	4,5	4,33	4,25	4,83	5,5	4,5
11	2,9	2,8	2,2	4,4	4,3	4,16	4,8	4,8	4

4. Conclusion

The data presented in this study showed that the addition of proteolytic enzymes, papain respectively, will cause softening of muscle tissue, resulting in increased tenderness of the meat preserved by vacuum packaging. Injection of adult beef with bromelain, $CaCl_2$ and NaCl did not lead to significant changes in meat tenderness, changes that had taken place in the myofibrillar system not sufficiently intense to cause softening of muscle tissue.

Vacuum packaging causes an increase in weight losses which may be considered a disadvantage of this method of conservation. Specific evolution of weight losses induced by vacuum packaging of meat is probably the effect of maintaining pH at low levels.

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