The evaluation of sensory properties of mature beef meat

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Abstract

Selected cuts of beef meat were evaluated – wing rib, top sirloin and flank – and their sensory properties compared during aging (30 days and 60 days). Measurement of the maximum Warner–Bratzler shear force determined that the meat became softer during aging, though this softening was not identical for all meat cuts tested. The samples measured after heat treatment showed greater changes during the experiment than the meat measured raw.

Dry aging, juiciness, meat colour, texture wet aging, tenderness

Introduction

The aging of meat is one of the most important factors influencing the palatability of meat and its acceptability to the consumer. The speed and progress of aging is influenced by the composition of the meat and the changes it undergoes during the aging process, in addition to the species of animal concerned. The significant constituents influencing the course of aging include the total protein content, the content of myofibrillar proteins and connective tissue proteins, intramuscular fat content and the energy reserves in the muscles in the form of glycogen. The process is accompanied with changes to all these basic constituents of the muscle, the most important of which include the gradual breakdown of the energy components of the muscle and changes to the myofibrillar proteins caused by the presence of lactic acid in the muscle and the associated fall in pH and the failure of calcium pumps in cell structures. During this phase, meat is in *rigor mortis* and is not suitable for culinary purposes. The gradual transformation of the muscle tissue in the meat and the formation of the characteristic culinary and technological properties of meat take place during the so-called aging of the meat. The speed of the aging process in meat depends, first and foremost, on the species of animal, the reserves of energy in the muscle and the temperature (Kameník et al. 2012). The meat of certain animal species, such as fish and poultry, ages extremely quickly only a few hours. In contrast, pork meat requires several days to obtain the optimum culinary properties, and beef meat as much as several weeks. The problem in this country is that beef meat gets to the customer just a few days after slaughter when it is still at the stage of *rigor mortis* or shortly afterwards, and certainly not when it has been appropriately aged. Beef has excellent organoleptic and nutritional properties, and it is a great shame that it remains rather neglected by consumers. One reason for the continuing lack of popularity of beef among consumers in this country is its poor sensory properties (e.g. toughness, lack of juiciness and tenderness) caused by the inadequate aging of the meat. The reasons for this before all due to organisational and economic reasons, as meat must be stored in cold stores for a certain period (several weeks) after slaughter, and this involves the costs of both energy and the necessary premises, and these costs must logically be reflected in the final price of the meat. Nevertheless, aged meat (sometimes also called matured meat) has recently been appearing on the market in this country and is slowly becoming popular among customers.

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Two main systems for aging beef meat are currently used around the world – wet aging and dry aging. Wet aging consists of vacuum-packing selected cuts of meat and storing them in cool storage at a temperature of 0 to 2 °C. When this aging method is used, the surface of the meat is wet as a result of the partial release of meat juice, hence the name wet aging. In contrast, dry aging involves the aging of large parts of the animal unwrapped and requires far more demanding storage conditions (constant temperature, low microbial contamination) to ensure standard meat quality. In dry aging, the surface of the meat is dry and the growth of microorganisms is therefore significantly restricted. A temperature of -0.5 to 1 °C is used, with a relative air humidity of 80 to 85%. A lower humidity may cause the meat dry too quickly and lose its juiciness. On the other hand, excessively high air humidity may result in the growth of moulds on the surface of the meat (Perry 2012). The air in the cooling box is sometimes microfiltered to ensure low microbial contamination (DeGeer et al. 2009). The disadvantages of dry aging are greater losses caused by the drying out of the meat, a change in surface colour and the formation of a crust which must subsequently be cut off. These losses increase proportionately to the time of aging (Laster et al. 2008 and DeGeer et al. 2009).

The majority of producers use wet aging because dry aging causes larger weight losses, as well as losses during subsequent meat cutting. Dry aging is, nevertheless, considered the better method, as the meat has a far more characteristic aroma and appearance (Laster et al. 2008). Meat that is aged in a vacuum has a sour aroma caused by the presence of lactoacidogenic microorganisms (Fadda et al. 2008). In view of this fact, an innovative method of aging meat has been proposed recently which combines the advantages of the two methods. This new method consists of packing meat in bags highly permeable to water vapour. These bags are commercially available under the brand names UMAi DrybagSteak, Tublin, MacPak, etc. This method simulates dry aging, while greatly restricting weight losses and possible microbial contamination (Dikeman et al. 2013).

The comparison of the sensory properties of meat aged in various ways is described in the literature. The differences in the sensory evaluation of dry-aged and wet-aged cuts of meat are not particularly strong. Most authors (Hildrum et al. 2009; DeGeer et al. 2009; Dikeman et al. 2013) note that consumers show a preference for dry-aged meat during sensory evaluation, largely thanks to its greater juiciness. DeGeer et al. (2009) mention a far more characteristic beef aroma in meat cuts that have been dry-aged than in vacuum-aged meat. This better aroma is caused by a higher proportion of esters and heptanes which, as volatile substances, contribute to meat aroma. When evaluating uncooked meat, the majority of evaluators preferred dry-aged meat. Differences in evaluated parameters between the aging methods were not statistically significant when heat-treated meat was assessed. A study performed in Sweden showed that 58% of consumers preferred meat aged in bags permeable to water vapour over meat aged in a vacuum. Dry-aged meat was also shown to be more tender ($P = 0.065$) and juicier ($P = 0.082$) in sensory terms, and this (dry-aged) meat was markedly preferred by women. Men showed no preferences (Li et al. 2013). Smith et al. (2008) and Laster et al. (2008) also studied the difference between wet and dry aging and reached similar conclusions. Clearly, either the end consumer is not capable of sensory differentiation between wet and dry aging, or there is no taste difference between them. The positive effect of bags permeable to water vapour was confirmed by DeGeer et al. (2009). He discovered a statistically significantly lower trimming loss in meat stored in bags permeable to water vapour after 21 and 28 days of aging at 2.2 °C and 50% relative air humidity. The use of permeable bags had no effect on the resulting palatability of the meat. No effect was observed on surface contamination by coliform microorganisms and lactic acid bacteria.

As has been noted above, the use of the given technologies for aging beef meat is becoming more widespread in this country. For that reason we decided to perform a

comparison of the sensory properties of selected cuts of beef (wing rib, top sirloin and beef flank) during aging.

Materials and Methods

Samples of three fresh cuts of beef meat (beef flank, wing rib and top sirloin) were vacuum-wrapped and stored for 60 days of the slaughter of a young Red Pied bull. The wrapped cut was a whole muscle including membranes and fat covering, as commonly sold in retail stores. Sensory tests, instrumental measurement of colour and instrumental measurement of texture (Warner-Bratzler test) were performed on the samples before and after heat treatment. The meat was stored at a temperature of +2 °C and the individual tests were performed 0, 30 and 60 days after slaughter, in all cases before and after heat treatment. The meat was cut against the meat fibre into slices 25 mm thick. A GARBIN 23GM UMI (Garbin, Inc., Italy) oven was used for cooking. Cooking took place in the grill regime at 220 °C. The samples were placed on a tray and grilled until a temperature of 40 °C was attained in the sample core. Then the samples were turned over and grilled until a temperature of 72 °C was attained in the sample core (Caine et al. 2003). After cooking, the samples were cooled and stored for 24 hours at +2 °C. Four trained evaluators took part in the sensory tests on raw and cooked meat, which were performed on pre-prepared forms according to five-point ordinal category scales, with the value 5 corresponding to the highest standard of the given property, the value 1 to the lowest standard of the given property (Table 1). Colour, appearance, aroma and consistency (by touch) were evaluated before cooking. Colour, appearance, aroma, consistency (by touch), texture (in the mouth), juiciness and taste were evaluated after cooking. Colour was measured on the surface of the samples and on a cut surface using a CM-5 spectrophotometer (Konica Minolta Sensing, Inc., Japan) with the values L*, a*, b* being evaluated using the SCE method without reflection, measurement aperture 8 mm. The outer surface and the cut surface of each sample were measured ten times in each case. The Warner-Bratzler method is a frequently used instrumental method of evaluating meat texture as it best correlates with the sensory evaluation of tenderness. The Warner-Bratzler method makes it possible to measure the force acting on a blade necessary to shear or cut through a sample of meat (shear force, cutting force). Measurement of the shear force can be used to model the behaviour of meat when a mouthful is bitten into for the first time (Saláková et al. 2013). Samples were cylinders 25 mm in diameter cut "with the fibre" for the measurement of texture. The measurement of the shear force according to Warner-Bratzler was performed on the samples prepared in this way on an Instron Universal Testing Machine 5544 (Instron Corporation, England). Values were recorded with the use of computer software (Merlin, Series IX). Each sample was measured at least six times, depending on the size of the sample. The results were statistically processed in Microsoft Office EXCEL 2010.

Results and Discussion

Sensory tests before heat treatment

The colour and appearance of all three retail cuts of meat evaluated (flank, wing rib and top sirloin) were evaluated as characteristically red, corresponding to the type of meat, without sinews and delicately fibrous throughout the experiment. Only the flank after 60 days was evaluated as merely satisfactory in colour and appearance. Aroma was evaluated as characteristic of beef, without any off-odours, in all the retail cuts. After 30 days, the aroma of top sirloin was evaluated merely as characteristic, while after 60 days it was again evaluated as characteristic of beef without off-odours. At the end of the experiment (day 60), a weak off-odour was found in beef flank, with the aroma being less typical. With the exception of top sirloin, in which the consistency was evaluated as appropriately soft at the beginning of the experiment, all the retail cuts showed a characteristic, soft consistency, commensurate to the type of beef meat on all the test days (Table 2).

Sensory tests after cooking

Colour and appearance after cooking were evaluated as entirely satisfactory or satisfactory, delicately marbled with fat or with a larger or smaller amount of fat, without sinews, and delicately fibrous in all samples throughout the experiment. Aroma was pronounced or less pronounced, characteristic or generally characteristic of beef meat, clean, without any off-odours. More pronounced changes were recorded for consistency. In the case of fresh meat, the wing rib was evaluated by touch as tougher; the flank and top sirloin soft after their cooking. After 30 days of storage, the flank and wing rib were evaluated as still soft considering their cooking, while the top sirloin was evaluated as rather tough.

Table 1. The scale used for the sensory evaluation of beef samples (Ingr et al. 2001)

Point value	5 – The best	4	3	2	1 – The worst
			Before cooking		
Colour and appearance	Characteristic red colour corresponding to type of meat, slight marbling, no sinews, delicately fibrous	Satisfactory colour, slightly more fat, no sinews, delicately fibrous	Lighter or darker colour, a permissible amount of fat, slightly sinewy, more coarsely fibrous	Colour defects, the occurrence of spots or stripes, a larger amount of fat, sinewy, more coarsely fibrous	Colour with more pronounced defects, excessive amount of fat, strongly sinewy, more coarsely fibrous
Aroma	Characteristic of beef meat with no off-odour	Generally characteristic, clean	Less characteristic, less clean, possible weak off-odour	Uncharacteristic, with an off-odour	Uncharacteristic, unclean, with a strong off-odour
Consistency (by touch)	Characteristic, soft, corresponding to the type of beef meat	Appropriately soft, generally characteristic	Tougher, uncharacteristic of the type of meat	Tough, strong fibres, uncharacteristic	Excessively tough, not corresponding to the type of beef meat
			After cooking		
Colour and appearance	Entirely corresponding colour, slight marbling of the meat with fat, no sinews, delicately fibrous	Corresponding colour, a slightly larger or smaller amount of fat, no sinews, delicately fibrous	A lighter or darker colour than desired, a generally permissible amount of fat, slightly sinewy, more coarsely fibrous	Colour defects, the occurrence of blemishes or stripes, more surface or intramuscular fat, sinewy, fibrous	Colour with more pronounced defects, excessive amount of fat, strongly sinewy, more coarsely fibrous
Aroma	Pronounced, characteristic of beef, with no strange smells of any kind	Less pronounced, generally characteristic, clean	Not particularly pronounced, less characteristic, less clean, possible weak strange smell	Uncharacteristic, with a strange smell	Not pronounced, not clean, with a strong strange smell
Consistency (by touch)	Commensurate to the type of meat and cooking, soft meat	Soft considering its cooking	Tougher meat	Tough meat with tough fibres	Hard, tough meat
Juiciness	Extremely juicy meat corresponding to the type of meat and its cooking	Juicy meat	Less juicy meat	Almost dry meat	Dry meat
Taste	Pronounced, strong, characteristic, with no off-flavour	Less pronounced, generally characteristic, no discernible off-flavour	Less pronounced, less characteristic, possible weak off-flavour	Not pronounced, uncharacteristic, evident off-flavour	An unpleasant or repulsive off-flavour

After 60 days, the flank and wing rib were evaluated as still soft considering their cooking, while the top sirloin was evaluated as soft, with a consistency commensurate to the type of part of meat and its cooking. The texture in the mouth of top sirloin at the beginning of the experiment and after 30 days of aging was evaluated as rather tough, less tender, with occasional tough bits; after 60 days of aging it was evaluated as corresponding to the

type of meat, soft, tender, without tough. At the beginning of the experiment and after 30 days of aging, the wing rib showed a texture soft considering its cooking, tender, and after 60 days of aging a texture corresponding to the type of meat, soft, tender, without tough bits. On all test days, the texture of the beef flank was evaluated as soft and tender considering its cooking. The wing rib was extremely juicy at the beginning of the experiment, while the top sirloin was evaluated as less juicy after 30 days of aging. In the other cases, the beef meat was evaluated as juicy. The taste of the fresh beef meat remained rather subdued even after 30 days of aging, still characteristic, clean, without a perceptible off-taste. After 60 days of aging, an improvement to the taste properties was seen in the bottom and top sirloin; the taste was evaluated as pronounced, strong and characteristic, with no off-taste. No change in taste was recorded in the beef flank (Table 2).

Table 2. The sensory evaluation of samples of beef meat before and after cooking during aging

Period of aging	Fresh meat			30 days			60 days		
Before cooking									
Sample of beef meat	Flank	Wing rib	Top sirloin	Flank	Wing rib	Top sirloin	Flank	Wing rib	Top sirloin
Colour and appearance	5	5	5	5	5	5	4	5	5
Aroma	5	5	5	5	5	4	3	5	5
Consistency (by touch)	5	5	4	5	5	5	5	5	5
After cooking									
Colour and appearance	4	5	5	5	4	4	4	5	4
Aroma	5	4	5	4	4	5	4	5	5
Consistency (by touch)	4	3	4	4	4	3	4	4	5
Texture (in the mouth)	4	4	3	4	4	3	4	5	5
Juiciness	4	3	4	4	4	3	4	4	5
Taste	4	4	4	4	4	4	4	5	5

The instrumental evaluation of colour

No pronounced change in colour was observed on the surface of the sample of beef flank. Higher values for red and yellow colours were found on cut surfaces. The colour of the flank surface after cooking showed no pronounced changes during the aging process; lower values were measured on the cut surfaces for lightness, and red and yellow colours. A certain increase in lightness and yellow colour values was observed in the wing rib during aging. After cooking, however, the wing rib appeared darker than at the beginning of the experiment, with a reduction to the values of red and yellow. Similarly, the top sirloin showed higher values for lightness after 60 days of aging. A higher value for the yellow colour was recorded on the surface than was the case for the fresh meat. After cooking, lower values were recorded in the aged top sirloin for lightness and yellow colour than was the case for the fresh meat. A lower value for red was observed on the cut surface (Table 3).

The instrumental measurement of texture – the Warner-Bratzler test

During the instrumental measurement of raw beef meat using the Warner-Bratzler test we recorded the greatest shear force required to cut through the sample in the flank and the smallest force in the wing rib. On the basis of these values, the wing rib can be considered to be the “the most tender”. A drop in the maximum shear force (i.e. the meat becoming more tender) was found during the experiment in all three cuts of meat tested, with the greatest difference between fresh meat and aged meat recorded in beef flank, the smallest difference in wing rib. Lower values were recorded in all samples after cooking than in a raw state.

Table 3. The instrumental measurement of L*, a*, b* values in samples of beef before and after heat treatment during aging

Period of aging		Fresh meat			30 days			60 days		
Sample	Colour characteristics	L*	a*	b*	L*	a*	b*	L*	a*	b*
Flank	Surface	50.08	5.17	0.27	53.91	3.97	0.62	50.29	5.35	0.42
	Cut surface	50.08	5.17	0.27	49.74	6.51	1.95	49.68	7.51	2.15
Grilled	Surface	55.14	3.96	3.69	54.66	3.58	3.09	55.09	3.92	3.23
flank	Cut surface	61.25	6.48	8.28	63.95	6.81	8.48	53.01	3.01	2.22
Wing rib	Surface	46.40	8.88	1.87	50.66	7.80	2.92	51.74	7.46	3.51
	Cut surface	46.40	8.88	1.87	50.14	7.38	2.20	50.86	8.58	3.46
Grilled	Surface	56.16	4.15	5.85	54.22	3.59	4.04	54.60	3.03	2.87
wing rib	Cut surface	63.13	8.04	10.16	62.00	9.14	9.97	55.00	3.57	5.16
Top sirloin	Surface	47.55	7.39	1.24	50.95	7.24	1.99	53.05	8.55	4.18
	Cut surface	47.55	7.39	1.24	49.07	9.99	3.07	49.13	8.90	2.80
Grilled	Surface	53.52	4.35	4.07	55.24	3.69	4.55	48.93	4.40	2.74
top sirloin	Cut surface	62.49	7.60	8.97	57.30	8.36	6.58	49.81	4.56	2.53

The aging of the meat and its becoming “more tender” or “softer” during the 60 days of testing was also confirmed. These effects of aging were more pronounced in all cases between day 30 and day 60 than during the first 30 days, and the lowest shear force was measured in all cases at the end of the experiment. In cooked samples, the greatest changes in shear force were recorded in wing rib, the smallest changes in top sirloin (Table 4).

Table 4. The measurement of texture by the Warner-Bratzler test during the aging of beef meat samples before and after heat treatment

	Maximum WB force (N)		
Sample/Period of storage	Fresh meat	30 days	60 days
Flank	291.54	203.37	217.16
Grilled flank	123.79	125.84	92.20
Wing rib	147.62	144.81	142.74
Grilled wing rib	137.46	126.08	100.88
Top sirloin	164.42	167.46	156.37
Grilled wing rib	154.11	148.61	128.19

From our results we determined that after 60 days of aging, the colour and appearance of raw wing rib and top sirloin was characteristically red, corresponding to the type of meat. Beef flank colour was evaluated as slightly worse than at the beginning of the aging process. This may be caused by the thickness of the muscle tissue, which is very thin in comparison to sirloin, and the fact that microbial and sensory changes occur more quickly in the flank. An improvement in sensory properties was noted in cooked samples, particularly in top sirloin and wing rib, in which aroma, texture and taste received a high score in comparison with fresh meat and meat after 30 days of aging. The smallest differences recorded by the evaluators were in beef flank. The excellent evaluation of particularly the taste, texture and juiciness of top sirloin is the result of the specific fat content in this retail cut which causes the given sensory properties. In contrast, beef flank is a thin muscle with a low fat content and long muscle fibres. For that reason, no pronounced improvement in the

parameters evaluated was recorded during the aging process. Beef flank is generally served cut into slices "against the grain" after cooking, in contrast to top sirloin and wing rib, which are generally served as steaks. A number of authors have studied the properties of beef meat during aging. Their results are, however, extremely difficult to compare as the methodology of sensory evaluation and the characteristics of the animals (rearing method, the age of the animals, breed) differ greatly, as does the evaluation of various muscle areas. The properties of top sirloin and wing rib under various aging conditions are most frequently evaluated in the literature. Comparison of "dry aging" and "wet aging" has determined that the sensory parameters (in particular aroma, tenderness and juiciness) fall during the first three weeks of wet aging and only begin to improve after that period. In dry aging, in contrast, these parameters improve gradually during the entire aging process (Lastner et al. 2008). We reached similar conclusions in our experiment, during which the evaluators recorded a fall in juiciness, taste and texture after 30 days of aging in comparison with fresh meat, particularly in top sirloin. A number of authors state that the optimum period of aging for beef meat is around 40 days, at which time the best sensory properties of meat have been demonstrated, regardless of the method of aging (Franco et al. 2009). The length of aging does not have a negative effect on the possible oxidation of fats during aging in a vacuum (Descalzo et al. 2005). Our experiment also demonstrates that meat showed better sensory properties after 60 days of aging than after 30 days of aging.

Many consumers in this country still believe that beef from Argentina or Uruguay, for example, is of a far higher quality than Czech beef. We must, of course, compare the meat of young animals from meat breeds reared in good hygiene conditions (preferably grazed animals). The post-slaughter treatment of the meat and the attainment of optimal maturity (regardless of the method of aging selected) is, however, also extremely important. It is extremely pleasing to see that producers in this country are beginning to introduce such modern technology to an increasing extent, and that meat of this kind is gradually finding its way to the customer. Consumers should now have no difficulty buying high-quality, aged beef from Czech breeders. So long as the method of feeding, slaughter and aging are correct, Czech beef steak should compare favourably with a steak from an Argentinean bull.

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