Comparison of instrumental and sensory evaluation of texture of cured and cooked beef meat

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The instrumental and sensory texture attributes of beef muscles (M. longissimus dorsi and M. semimembranosus) were compared after curing and thermal treatments. Shear, compression and puncture tests were carried out with an UTM Instron 4301 and the sensory evaluation was made with the score method. The force values obtained for puncture test gave a greater degree of correlation with the sensory tenderness and thermal treatments. Shear, compression and puncture forces were found to significantly correlate with sensory tenderness only for muscles with perpendicular orientation of fibres to the direction of shear blade movement. The evaluation of beef texture with compression test was dependent on the level of sample deformation degree. The force values of compression were found to correlate significantly with elasticity and juiciness of meat up to 60% deformation levels, but at deformation levels higher than 60% appeared significant correlation with tenderness and hardness. The obtained results showed the usefulness of puncture test with proposed parameters for the instrumental measurements of beef texture.

1 Introduction

Texture takes a significant part in the quality acceptance of food products. It is a group of properties resulting from natural structure of the food elements, their mutual arrangement, interaction and way in which they are perceived by the human senses [5, 14, 25]. Texture is also the attribute deciding about meat and meat products quality. It depends on many factors such as: chemical composition, structure, physical properties, processing methods, shape and many others, which mutual relationships and intensity designating this property as complex and thereby difficult to univocal defining. Texture involves such attributes as hardness, tenderness, fibrousness, guminess, elasticity, firmness, juiciness and many others [2, 3, 12, 15, 25]. In evaluation of meat product quality, texture takes usually the second place after flavour [4, 11, 20].

Meat texture results from the influence of basic actomyosin factor and connective-tissue factor, which is supplementary. Meat texture highly correlates with water absorption and swelling indices of proteins. This first factor influences the tenderness of beef more than pork [21, 23, 24, 29]. According to Bouton and Harris [6], the meat texture depends on two factors: the cohesion between muscle fibres and the strength of fibres itself.

Texture is the category of quality, which is perceived, first of all, kinaesthetically. The instrumental measurements are however necessary for describing this complex attribute by numerical values, thus giving for texture a quantitative meaning. Instrumental methods of texture measurement have an advantage over sensory methods, because they are less time consuming, cheaper, more repeatable, free from variability caused by psychological, physiological and environmental factors influencing the human responses. On the other hand, the advantage of sensory methods over instrumental methods of texture measurement is the complexity of perception, enabling an immediate analysis, integration and interpretation of a large number of single textural sensations at the same time. Some aspects of this complex evaluation can be simulated during instrumental measurements, but a complete reproduction of sensory testing is impossible. Therefore, most often instrumental and sensory investigations are conducted simultaneously and correlations between them are determined [3, 8, 17, 24, 25].

In recent years, the texture studies of the cured pork products attract a great interest [9, 10, 13, 18, 19, 27, 28]. In the investigations of meat texture, not much attention is paid, as yet, to cured beef products. The effect of curing salts on the meat texture development is very important. Thus, it seems justifiable to verify the usefulness of instrumental tests and their correlation with results of the sensory evaluation of texture for cured and thermally treated beef. This was the purpose of the present work.

2 Material and methods

2.1 Material

The material for investigations was beef derived from heifers, polish black-white breed, with mass of 350–400 kg and age of 18–20 months. The meat was characterized by pH values from 5.5 to 5.7. The brine contained 16% NaCl and 0.115% NaN02. The samples were cured for 96 h at 4°C. Batch weighed about 330 g. The obtained preserves were cooled in a running water at 10°C for 3 h, and then stored at 4°C until analysed. The experiment was conducted in six repetitions.

2.2 Methods

Instrumental measurements of beef texture were conducted using an UTM Instron 4301 with an Instron IX Series, version 5.02 software. The 1000 N load cell with crosshead speed of 50 mm/min was used for the shear, compression and puncture tests. Before the shear and compression tests, the meat samples were cylindrically shaped by cutting parallelly or perpendicularly to the orientation of muscle fibres. In the shear test, the samples (10 mm in diameter) were cut by a 1 mm thick shear blade of a Warner-Bratzler Meat Shear (type 2830-013) device.
In the compression test, the cylindrical samples with 10 mm diameter and 10 mm height were placed on the sample support plate and compressed to 80% (from 10 to 2 mm) by a simple compression anvil (type 2830-01) with 30 mm diameter. Force-deformation curves were registered.

In the puncture test, 10 mm thick slice of meat was placed over a 15.3 mm i.d. hole in the sample support plate and a flat plunger (diameter 12.6 mm) centredly positioned over the hole was driven completely through it. The meat slices with parallel and perpendicularly oriented muscle fibres to the working plunger were tested [2, 17, 24].

Sensory analysis was conducted by six trained panelists, using the method of chosen textural attributes with 1–5 point scale [1]. Tenderness, hardness, elasticity and juiciness of the meat samples were evaluated. The temperature of meat samples subjected to instrumental and sensory evaluation was 20 ± 0.5°C.

Statistical analysis of the results was carried out with an ANOVA. The mean values were compared using the Student’s t-test. The correlation coefficients (and their significance at P < 0.05) between sensory and instrumentally evaluated attributes of beef texture were calculated [22].

### 3 Results and discussion

The shear force values needed to 50% deformation and cutting the meat samples are shown in Table 1. The maximum shear forces for perpendicular cutting ranged from 42.5 to 51.6 N and those for parallel cutting needed lower forces ranging from 29.4 to 39.3 N. The forces necessary to 50% sample deformation were lower about two times, at similar proportions between the force values for samples with perpendicular and parallel orientation of muscle fibres.

Average variation of results was relatively low for maximum shear forces, oscillating from 9.1 to 19.1%; for 50% deformation forces it was however higher (from 11.1 to 18.2%). The maximum shear forces, perpendicular to the orientation of muscle fibres of the tested meat, correlated significantly (P < 0.05) with the results of the sensory-evaluated tenderness (Tab. 1, 3, 4). Strong relationships between the shear force values and results of the sensory hardness and tenderness of beef were also reported by Brady and Hunecke [7]. The maximum shear forces, parallel to the orientation of muscle fibres did not correlate significantly (P < 0.05) with any of the sensory attributes of the meat samples tested.

It results univocally, that the shear test of thermally-treated beef should be conducted for perpendicularly oriented muscle fibres, because only in this case it can project the tenderness perceived by the sensory analysis. This conclusion relates only to meat, which tenderness is determined by state of myofibrillar proteins, but not by connective tissue proteins. Therefore, we can not exclude the correlations for muscle fibres of meat, the tenderness of which depends to a greater degree on connective tissue hydrolysis. Similar suggestions were put forward by Tyszkiewicz [26], Young and Braggins [29] and Magoli et al. [16].

Table 2 shows, in analogous arrangement, average values of puncture test for the meat slice. The obtained values of yield point force were higher than maximum shear forces and for the samples with perpendicularly orientation of muscle fibres to the working plunger were 64.5 and 80.7 N, while for the samples with parallel orientation of fibres they were 40.0 and 62.0 N. Lower values of variation coefficients were obtained for puncture test than for the shear test (from 3.7 to 11.7%) (Tab. 2).

The 50% deformation forces were about two times lower than the yield point forces for meat samples with perpendicular orientation of fibres and they were about one fourth of the yield point forces for the samples with parallel orientation of fibres. Relatively low values of 50% deformation forces resulted from the initial deflection of samples and not before the plunger was moved more, typical punching with needed higher forces was followed.

The force values obtained during puncture test of the meat slice placed perpendicularly to the orientation of fibres were characterized as having high correlation coefficients (P < 0.05) with the results of sensory-evaluated tenderness, hardness and elasticity for meat from both kinds of the beef muscles tested. The values obtained in the puncture test for the samples placed

### Table 2. Parameters of beef puncture test (n = 36).

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Orientation of fibres</th>
<th>Statistical Max. of fibres force [N]</th>
<th>Displacement force at max. yield [mm]</th>
<th>Force at 50% deformation [N]</th>
<th>Energy at 50% deformation [J]</th>
</tr>
</thead>
<tbody>
<tr>
<td>LD</td>
<td>pd</td>
<td>x 64.5*</td>
<td>21.0*</td>
<td>0.28*</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>v [%] 13.4</td>
<td>16.3</td>
<td>10.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>pl 40.0*</td>
<td>16.5*</td>
<td>0.15*</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>v [%] 19.1</td>
<td>17.8</td>
<td>22.4</td>
<td></td>
</tr>
<tr>
<td>SM</td>
<td>pd</td>
<td>x 80.7*</td>
<td>24.2*</td>
<td>0.33*</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>v [%] 9.1</td>
<td>11.1</td>
<td>15.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>pl 62.0*</td>
<td>24.5*</td>
<td>0.24*</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>v [%] 13.4</td>
<td>18.2</td>
<td>25.0</td>
<td></td>
</tr>
</tbody>
</table>

Explanations: pd-perpendicular, pl-parallel, abcd-means in the same column, with different superscripts differ (P < 0.05), x-mean value, v-coefficient of variation.

### Table 3. Average values of beef sensory evaluation (n = 36).

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Tenderness</th>
<th>Hardness</th>
<th>Elasticity</th>
<th>Juiciness</th>
</tr>
</thead>
<tbody>
<tr>
<td>LD</td>
<td>3.05*</td>
<td>2.76*</td>
<td>3.87*</td>
<td>2.90*</td>
</tr>
<tr>
<td></td>
<td>v [%] 15.92</td>
<td>11.57</td>
<td>14.70</td>
<td>16.88</td>
</tr>
<tr>
<td>SM</td>
<td>2.53*</td>
<td>3.42*</td>
<td>3.78*</td>
<td>2.07*</td>
</tr>
<tr>
<td></td>
<td>v [%] 10.33</td>
<td>10.76</td>
<td>17.84</td>
<td>13.54</td>
</tr>
</tbody>
</table>

ab-means in the same column, with different superscripts differ (P < 0.05), x-mean value, v-coefficient of variation.

parallelly to the orientation of fibres did not correlate significantly (P < 0.05), in most cases, with sensory evaluation results. The puncture or shear test values and meat juiciness were also found not to correlate significantly (Tab. 3, 4).

The correlations between the maximum shear force values and sensory tenderness are similar to those reported by Beilken et al. [2], however in mentioned work lower values of correlation coefficients were significant (P < 0.05) with elasticity and juiciness, but not with tenderness and hardness, of both tested muscles. At 60% deformation level, the force values correlated significantly (P < 0.05) with elasticity and tenderness of both muscles and with juiciness of the LD muscle. At 70 and 80% levels of compression, the correlation coefficients were significant (P < 0.05), except one case, for tenderness (from −0.81 to −0.65) and hardness (from 0.75 to 0.90). No correlations were found for elasticity and juiciness of samples with the studied compression levels (Tab. 3, 4).

4 Conclusions

- The maximum shear forces of beef were found to correlate with sensory tenderness only for muscles with perpendicular orientation of fibres to the direction of shear blade movement.

- The results obtained in the puncture test of meat slice were found to correlate with sensory tenderness and, only for samples with perpendicular orientation of muscle fibres, with hardness and elasticity. The proposed parameters of puncture test are thus useful for instrumental measuring the texture of cured cooked beef.

- The proper texture evaluation of beef with the compression test needs, first of all, the selection of sample deformation degree, because the forces necessary to compress the sample at different deformation levels were found correlate with different sensory-evaluated attributes.

References


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