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RHEOLOGICAL CHARACTERISTICS OF FRESH, HEAT PROCESSED BEEF PRODUCTS AND THEIR RELATIONSHIP TO TENDERNESS MEASURED BY SENSORY METHODS

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ABSTRACT

The rheological characteristics (measured as shear force on an instron apparatus model 1140) of biceps femoris muscles of beef after heat treatments at 115°C in stationary and rotating autoclaves, 125°C in stationary and also 125°C but higher F_o value in stationary and rotating autoclaves were studied.

In parallel tests, sensory evaluations of tenderness of the same muscle was carried out and the results were compared with those obtained using the instrument. Results showed that the methods of heat treatments were reflected in the shear force values. For instance beef samples autoclaved at 115°C in stationary position (MA1) had a mean shear resistance of 84.76N which was lower than that autoclaved at the same temperature but rotating position (MF 2) which was 98.68N while that of the raw sample (M) was 32.76N. The beef sample (MA3) autoclaved at 125°C in stationary position had a mean value of 164.25N compared to that of the raw sample (M) which was 18.65N. Beef sample MF5 autoclaved at 125°C in rotating position had a mean value of 95.53N which was higher than that of sample MA4 (94.61N autoclaved at the same temperature but in stationary autoclave while that of the raw sample (M) was 28.26N.

The results of sensory evaluation scores of tenderness showed that beef samples MA1 and MA4 autoclaved in stationary position but different temperatures 115°C and 125°C respectively were scored the same 29 points while sample MA3 autoclaved at 125°C but lower F_o value though stationary had a score of 16 points. Samples MF2 and MF5 autoclaved in rotating position but at different temperatures 115°C and 125°C (higher F_o value) scored 23.5 and 21.5 points respectively.

The result of rank correlation between organoleptic and instrumentally measured texture of autoclaved beef samples was found to be equal to
-0.826(+) indicating negative correlation which was significant ($P < 0.05$).

Application of various technological treatments show that similar texture changes could be detected whether sensory methods or instrumental measurements were applied.

It may be concluded that shear force measurement of beef reflects to some extent the sensory perception of tenderness justifying the use of the instrumental method.

KEY WORDS: Heat treatment, Canned beef, Rheological Characteristics, Shear force.

INTRODUCTION

The importance of physical properties to consumer acceptance of meat, has precipitated to the search for a method for determining quickly and accurately a parameter or parameters of raw (meat) muscle that will predict the texture of cooked meat. Boyde and Sherman, (1975) suggested that other avenues should be pursued, particularly those that tend themselves to modern instrumentation and data processing. Cardello et al (1982) stated that humans evaluate food texture by integrating their responses to several sensations resulting from the reaction of food to mastication, while Bourne and Comstock (1981) said that a simulation of the sensory summation process was achieved by applying instrumental texture profile analysis to two successive compression cycles imposed on the food. Peleg, (1980) explained that force-deformation curves are analyzed in terms of several parameters that related to sensory scores.

In certain foods and under specified conditions of geometry and testing, emperical instruments may give good correlations with sensory rating. The rheological analysis of such instruments can be valuable in designing of testing probes which use well defined physical measurements, and which are applicable to a wider range of foods, geometrics and testing conditions. Voisey and his co-workers have reported on the mechanical analysis of some emperical instruments used by the Food Industry (Voisey 1976a; 1977, Voisey

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and Crete 1973; Voisey and Larmond 1974; Voisey and Klock 1978; Voisey et al. 1975).

Rheological characteristics of muscles measured by instrumental methods do not reflect in all complexity the sensory perception of tenderness. However, simplicity, reproducibility of results and objectives are unquestionable advantages (Calzada and Peleg, 1978).

By direct observation, Voisey, (1976b) found that the recorded forces from the Warner-Bratzler shear apparatus and a punch and die do not indicate the shear rupturing characteristics of meat. Rather. rupture occurs under complex stresses (tension, shear; compression and flow) in a situation difficult to analyze. the Warner-Bratzler apparatus cuts the meat in two places, not the single plane normally assumed.

Bourne, (1977b) stated that a partially successful application of the rupture test in predicting consumer response was found in the Warner-Bratzler shear, which is widely used for measuring the toughness of meat. Szczesniak and Torgeson, (1965) reviewed the literature in which correlations between Warner-Bratzler shear and sensory assessment of meat tenderness were published, correlation coefficients ranged from -0.001 to -0.942. Of the fifty one papers surveyed, forty-one reported good agreement or better, and the remainder indicated that correlation was borderline to poor. They commented further that it was difficult to account for the variability because so many factors come into play, not the least of which is the reliability of the taste panel as well as the parameters it measures.

The progress in animal husbandry and the development of new breeds and hybrids brings about the necessity of objective quality assessment of animal raw and processed products, using objective and comparable quality characteristics whenever possible. A demand for objective quality assessment concerns also the development of new preservation and storage techniques as well as technological processes. This necessitated the objective of the research on the influences of technological processes on the rheological properties of beef product (Eneji, 1985).

MATERIALS AND METHODS

Beef from which the bones, tendons, surface connective tissues and fat had be removed was use. Deboning and removal of unwanted tissues were done manually with the aid of a sharp knife. The beef was the biceps femoris muscle of the animal.

Preparation of sample

The beef was washed with warm, tap water and then cut into cubes (24 × 24mm) through a 24mm disc. The beef was mixed with 10g/kg table salt. Four hundred gram of the mixed meat was filled into five hundred gram of internally lacquered can (Ø99 × 60mm) with Vemag machine and sealed hermatically.

Sterilization of the samples took place both in the Research Institute for canning - and Paprika Industry and in Budapest canning factory in Hungary.

The samples without heat treatment-control - were stored frozen until rheological investigations.

Stock Pilot Rotor model 900 laboratory and LW 2002 Lubeca stationary autoclaves were used under factory conditions to sterilize the samples.

The beef product received five types of heat treatments: at 115°C in stationary and rotating autoclaves, 125°C in stationary autoclave and 125°C but higher F_o value (time in minutes required to destroy microorganisms at 121.1°C) in stationary and rotating autoclaves.

Instrumental determination of rheological characteristics:

The investigations were carried out on an instron Universal testing machine-WARNER-BRATZER shear device type 1140. The device, a pair of scissors were mounted on the cross head of the machine and used with a cross head speed of 20cm/sec. Changes in the force applied to the sample by horizontal crosshead and shearing blunt edge were observed with a strip-chart recorder which plots a force vs. time curve for every test.

The samples of meat sheared at right angles to the fibre axis were cut to about 0.013 × 0.013M by the Warner Bratzler shear device. The maximum force for shearing the samples as well as the work of shearing were determined that is the area under the curve shear vs. time was measured by planimetry. The shear force characteristic of the texture was given in Newton.

Sensory Evaluation

Sensory evaluation was by an experienced 8-member panel. Five texture characteristics were evaluated based on colour, flavour, number of chews, remains alter chewing and tenderness. Results of sensory analysis method were evaluated using KRAMER'S (Banyai and Perczel, 1983). Every technological treatment was

Table 1: The formation of shear resistance of beef samples (in Newton)

Product designation	Mean	Dispersion	Standard Error (S.E)
M	32.76	12.80	±2.47
MA1	84.74	27.76	±3.60
MF2	98.68	37.76	±4.1
M	18.65	12.60	±1.05
MA3	164.25	31.84	±6.25
M	28.26	9.28	±1.60
MA4	94.61	30.92	±3.98
MF5	95.53	38.16	±3.65

	115°C		125°C	125°C		
	Stationary	Rotating	Stationary	Stationary	Rotating	Fresh
Beef	MA1	MF2	MA3	MA4	MF5	M

Table 2: Comparison of the heat treated canned beef samples to raw meat and in pairs with

t-test based on the mean values

Product designation	M	MA1	MA4
MA1	7.50^{+++}		
MF2	5.39^{+++}	1.03	
MA3	13.53^{+++}		
MA4	10.67^{+++}		
MF5	6.89^{+++}		0.008

$^{+++}$Significant at $P < 0.1$

evaluated in three replicates and t-test was used in the statistical analysis.

Results and Discussions

The results of the mean and dispersion of shear resistance of beef samples are summarized in table 1. Results show that the methods of heat treatments were reflected in the shear force values. Beef sample autoclaved at 115°C in a stationary position (MA1) had a mean shear resistance of 84.76N and a dispersion value of 27.76 which was lower than that autoclved at the same temperature but rotating autoclave (MF2) that was 98.68N and dispersion of 37.76, while that of the raw sample (M) was 32.76N and dispersion of 12.80. The beef sample (MA3) autoclved at 125°C in stationary position had a value of 164.25N and dispersion of 31.84 was higher than that of sample (MF2) which was 95.53N autoclaved at the same temperature but rotating position. This reveals that the method of heat treatment had adverse effect on the shear resistance.

The t-test values for the comparison of the autoclaved and raw beef samples are shown on table 2. Again meat product MA3 had a significant ($P < 0.1$) t-test values showing a strong positive relationship between the autoclaved and raw samples. However, there was no significant ($P > 0.05$) difference between meat products MF2 and MA1 as well as between MA4 and MF5. The reason being that the heat treatments were not too severe on the samples. Therefore the t-test values were not significantly different.

The sensory scores for all the products are summarized in table 3. Meat product MA1 had a highly significant ($P < 0.01$) sensory score for colour followed

Table 3: Evaluation by ranking according to KRAMER of the sensory scores assigned to canned beef samples

Properties studied	Samples				
	MA1	MF2	MA3	MA4	MF5
	Rank Sum				
Colour	36.5^{++}	17	21.5	30	25
Flavour	21.5	24	12^{++}	28	33.5^{+}
Number of chew	16	23	12^{++}	32	37^{++}
Remains after chewing	16	25	14^{+}	29	35.5^{++}
Tenderness	29	23.5	16	29	21.5
Total point per sample	18	21.5	12^{++}	33	37.5^{++}

Number of panel members (n = 8)

$^{+}$ = $P < 0.05$

$^{++}$ = $P < 0.01$

$^{+++}$ = $P < 0.1$

Table 4: Rank Correlation between organoleptic and instrumentally measured texture of heat treated beef samples

ROW NUMBER studied	RANK NUMBER			
	Mean sensory panel rating	Mean Shear force value	Idl	d2
1	1.5	5	3.5	12.25
2	3	2	1	1
3	5	1	4	16
4	1.5	4	2.5	6.25
5	4	3	1	1

$r_{rank} = -0.825^{(*)}$

(* P = 0.051)

by a none significant (P > 0.05) colour scores for MA4, MF5, MA3, MF2. The variations in sensory scores for colour could be attributed to the methods of sterilization be stationary or rotational. For product of this type (meat in its juice) heat penetration is by conduction which is more effective in stationary autoclave resulting in acceptable colour than rotating autoclave where the rotation of the autoclave does not allow sufficient time for heat to penetrate the product and this results in unacceptable colour.

On flavour meat product MF5 had the highest sensory score followed by MA4, MF2 and followed by MA4, MF2 and MA1 while MA3 had the lest but highly significant (P < 0.01) sensory score on flavour. This may be due to the stationary autoclave and temperature of heat treatment.

Similarly, on number of chews and remains after shewing, meat products MF5 and MA3 had highly significant (P < 0.01) scores whereas, samples MA1, MF2 and MA4 were non-significant for these properties. The variations in these results can be attributed to the temperature of sterilization which was low for products MA1 and MF2 while that of MA4 can be attributed to the method of sterilization which was stationary.

On the other hand, tenderness was found not to be significant (P>0.05) for all the meat products irrespective of the temperature used for canning. This was due to the methods of heat treatment.

The results of rank correlation (table 4) between organoleptic and instrumentally measured texture of autoclaved beef samples was found to be equal to -0.826(+) indicating negative correlation and also highly significant (P < 0.01).

CONCLUSION

Application of various technological treatments show that similar texture changes could be detected whether sensory methods or instrumental measurements were applied.

It may be concluded that shear force measurement of beef samples reflect to some extent the sensory perception of tenderness justifying the use of the instrumental methods.

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