

## SESSION 4. FRESH MEAT TECHNOLOGY

### 4:1

#### RELATIONSHIPS BETWEEN MECHANICAL PROPERTIES OF RAW MEAT AND CHARACTERISTICS OF CONNECTIVE TISSUE

Abustam E., Bordes P., Culioli J.

Station de Recherches sur la Viande, I.N.R.A.,  
Theix 63122 Ceyrat (France)

Muscles or muscle masses are being used increasingly in meat marketing. This means that individualized muscle quality has to be characterized. Among the quality criteria, potential muscle tenderness can be used to classify raw muscles by categories which do not exclusively depend on anatomical features. Furthermore, tenderness is highly useful because it can determine the most appropriate type of technological treatment that should be used (i.e. mincing, mechanical tenderizing, cooking) and its conditions for use. Potential tenderness depends on intramuscular connective tissue characteristics. The aim of this study was to analyse the relationships between the mechanical properties of raw muscle and connective tissue characteristics, and determine whether a non-destructive mechanical method could be used to evaluate their potential tenderness.

Longissimus dorsi (LD), Semitendinosus (ST), Triceps brachii caput laterale (TB) and Pectoralis profundus (PP) muscles from 10 animals (cull cows and young bulls) were used. The mechanical behaviour of muscles was analyzed under sinusoidal compression in a transient state with a cell that took into account anisotropy of muscle tissue. The mechanical resistance and elasticity of raw samples were determined with destructive and non-destructive tests. Collagen content was determined. Connective tissue was characterized by measuring its degree of solubility, as well as by determining the linear density of its network, estimated by the number of primary bundles per length unit.

In the non-destructive compression tests (20%), the collagen fibers in the connective network did not

appear to be under strain. No relationship was noted between the mechanical parameters (resistance and elasticity) determined on raw meat and the collagen content, or the different characteristics of connective tissue. Still, there was a correlation between content and mechanical resistance when the compression ratio increased. This correlation reached its highest value under a 60-70% compression. Thus, during destructive compression tests (80%), variations in collagen content explain 66% of the variations in mechanical resistance ( $r = 0.81$ ). The relationship between collagen content and elasticity is, however, not as tight ( $0.5 < r < 0.6$ ). The correlation coefficient between the linear density of the primary perimysium network and collagen content is nearly 0.5. Yet, the informations on collagen content given by mechanical measurements are not improved when linear density is taken into consideration. No relationship was found between the different mechanical parameters used on raw meat and the solubility of collagen, which is an important component of cooked meat tenderness.

Compression was concomitant with a free deformation of the sample, perpendicular to the axis of the imposed compression. This brought on a stretching of the connective network. At low compression ratios ( $\leq 20\%$ ), the meshes in the network were deformed, but collagen fibers were not directly strained. To characterize the resistance of these fibers, the network has to undergo tension first. This can be achieved only when compression is around 30%, which does not induce any apparent breaking in samples. So, a non-destructive mechanical test should be used in this range of compression. The application of such a test to the entire muscle meets with additional problems in connection with myofiber orientation and deformation characterization.

### 4:2

#### THE EFFECT OF ANTIOXIDANTS ON THE STORAGE LIFE OF RESTRUCTURED PORK CHOPS

Marriott, N. G. and Graham, P. P.

Department of Food Science and Technology, Virginia Polytechnic Institute and State University,  
Blacksburg, Virginia 24061, U.S.A.

The effectiveness of certain antioxidants on the stability of frozen cuts of meat is not known. Thus, restructured pork was manufactured using boneless, flaked shoulders with various adjuncts to determine their value for protecting appearance traits and taste attributes during frozen storage.

The adjuncts evaluated in Study A were butylated hydroxyanisole (BHA), ascorbic acid (AA), and BHA+AA and sodium tripolyphosphate (STP). Potassium chloride (KCl), STP and lecithin were evaluated in Study B. Objective and subjective evaluations were conducted for quality attributes such as color, cohesiveness, overall appearance, flavor, juiciness, texture and oxidative rancidity.

According to Study A, the use of BHA alone and in combination with STP and/or AA was effective in maintaining acceptable color and flavor and low oxidative rancidity (TBA values) for up to 60 days. Samples with STP and AA maintained acceptability of these traits for 30 days, although AA alone was less effective. The best results were obtained with BHA, AA and STP in the formulation. Objective and subjective measurements of color and other visual traits revealed that storage time affected these attributes more than the adjuncts; whereas, all treatments had a minimal effect on texture and juiciness.

Results from Study B revealed that 0.5% of KCl can be successfully incorporated in the formulation as a substitute for NaCl. Increased frozen time and lecithin contributed to flavor degradation and increased TBA values. This observation was attributable to the failure to incorporate the optimal amount of this potential antioxidant.

These studies supported the conclusion that (1) BHA, AA and STP can increase the stability of restructured pork chops during storage; (2) 0.5% KCl can be substituted for NaCl in a restructured pork formulation; and (3) additional research is needed regarding the viability of lecithin as an antioxidant for restructured pork.

### 4:3

#### RECENT ADVANCES IN FRESH MEAT TECHNOLOGY

Paardekooper, E.J.C.

Netherlands Centre for Meat Technology, TNO-CIVO Institutes, Zeist, The Netherlands

Today's food industry derive great benefit from the rapid progress of electronics. Even more significant in engineering is the impact of the computer, changing our way of thinking and becoming an integral part of almost every problem-solving approach. It is generally accepted that computers have moved into the forefront of technology. Apart from the rapid development of electronics, new working techniques like high pressure water jet and laser became available for the industry together with processing techniques such as (co)extrusion and meat-bone separation by pressure. All this enabled the meat industry to proceed faster with the application of computerization and robotics. In combination with sensor technology, the simple butchery operations and slaughter processing have proved to be accessible to automation.

Current packaging and presentation methods are of much benefit lengthening the shelf life, reducing weight loss and achieving a better appearance of fresh meat. The combination of controlled atmosphere packs, flexible packaging materials and automated packaging systems is a definite advance.

Besides the progress in technology, consideration should be given to the development of new products. In addition to the artisanal way of product development for the fresh meat market there is the more promising approach of binding raw meat cuts and trimmings in order to obtain a new range of composite raw meat products.

### 4:4

#### MODIFYING THE TEXTURAL CHARACTERISTICS OF FORMED BEEF PRODUCTS

Bernal, V. M., Bernal, W. U. and Stanley, D. W.

Department of Food Science, University of Guelph, Guelph, Ontario, Canada. N1G 2W1.

Some of the factors affecting the textural characteristics of formed beef products were investigated. In the first part of the study, an evaluation was made of the contribution of the connective tissue present in the raw material to the texture of the finished product. The feasibility of reducing this contribution through the application of a bacterial collagenase to the formed product was also examined.

In the second part of the study, improved binding among the formed meat pieces was attempted by incorporating several nonmeat ingredients. The strength and stability of the bind effected in these products were compared to the binding characteristics obtained with the heat-set mechanism usually relied upon in restructured meat products. This mechanism involves salt-extracted myofibrillar proteins.

The formed products were manufactured as follows. Frozen commercial beef fronts were cut into small cubes and flaked in an Urschell Comitrol. The flaked meat was mixed with one or more of the following ingredients: sodium chloride, calcium chloride, a bacterial collagenase, alginate, methylcellulose, whey protein, and a combination of egg white, gluten and calcium oxalate. The mixtures were then

The following recent developments in connection with the afore mentioned new techniques are described.

- The first tentative steps in automation of several unit operations of the slaughter and cutting line.
- The use of a high pressure waterjet system to clean the carcasses after singeing (flaming) instead of mechanical scraping.
- A video image analysis system to replace human observation in cutting operations.
- A specialized sensor system to measure the evaporation of water from the meat surface - "The evaporimeter".
- A new method which consists of packing individual cuts in evacuated bags and then putting each of these skinpacked cuts in a foil laminated bag that is evacuated and flushed with CO<sub>2</sub> and sealed. This flexible modular vacuum and gasflushing system for meat cuts can double the storage life of red meat compared with current vacuum packaging methods.
- The development of new fresh-(raw) composite meat products using the combination of fibrinogen as substrate and thrombin as enzyme to form a glue for the binding of meat trimmings and raw meat cuts.

stuffed, stored at -30°C, tempered to -4°C, pressed, stored again at -30°C, sliced, vacuum packaged and stored at -30°C for the duration of the study. Texture was evaluated using instrumental techniques which measured tensile strength and Warner-Bratzler shear-forces. Some of the samples were also compared using sensory evaluation.

It was found that while some level of connective tissue toughness was desirable in these products, excessive levels resulted in an objectionable texture. Significant reductions in connective tissue toughness, as measured by the instrumental methods used, were produced by collagenase treatment. However, factors such as enzyme cost and safety must be taken into account before future applications could be considered.

Some of the alternative binding systems used were as effective as sodium chloride in providing an intimate bind between the meat pieces; further development may lead to their industrial utilization. The success of these binders was believed to rely on their ability to interact with the meat proteins present at the meat particle interface to form an ordered and heat-stable three-dimensional network structure.

#### 4:5

##### IRRADIATION OF VACUUM-PACKAGED SHEEP CARCASSES TO EXTEND CHILLED STORAGE LIFE

Beilken, S.L., Bill, B., Grau, F.H., Griffiths, I., Macfarlane, J.J., and Vanderlinde, P.

CSIRO Division of Food Research, Meat Research Laboratory, Cannon Hill, Queensland, Australia

and Wills, P.A.

Australian Atomic Energy Commission, Lucas Heights, N.S.W., Australia.

In view of the recently improved prospects for the acceptance of the gamma irradiation of foods by regulatory authorities, a study has been carried out into the use of this treatment to extend the storage life of vacuum-packaged lamb carcasses. In this study, 63 lamb carcasses were vacuum-packaged in a commercial abattoir, and 21 carcasses allocated to each of the following treatments: (i) gamma-irradiated (2 kGy approximately, using cobalt-60) and stored at 0-1°C (irradiated); (ii) non-irradiated and stored at 0-1°C (control); and (iii) non-irradiated and stored frozen at -20°C (frozen control). At regular intervals up to 16 weeks' storage, 3 carcasses were removed from the irradiated and the control treatment groups and the following assessments made: (i) appearance of the carcasses; (ii) confinement odours at the time packages were opened; (iii) the volume of weep; (iv) the microbiological status of the carcass; (v) the taste and odour of the cooked meat (frozen controls were included in this comparison).

The main findings of the study were:

- (i) Irradiation was generally thought to have a beneficial effect on the appearance of the carcasses in their vacuum packages, probably

attributable to the development of a slight pink colouration of the adipose tissue.

- (ii) The odour produced as a result of the carcasses being irradiated detracted from the acceptability of the raw meat, but off-odours as a result of microbial spoilage were a greater detraction in control samples after some weeks' storage.
- (iii) Irradiation increased weep during storage.
- (iv) Microbial growth on the irradiated samples was significantly slower than on the controls. After attaining a population of approximately  $10^7$  organisms/cm<sup>2</sup> in approximately 4 weeks, microbial numbers on the control samples increased little, if at all, over the time until the experiment was terminated at 16 weeks. In contrast, microbial numbers on the irradiated samples increased throughout storage, but by 16 weeks were still only about  $10^5$  organisms/cm<sup>2</sup>.
- (v) In comparisons with the control and the frozen control treatments, the irradiation treatment was judged by a taste-panel to have a detectable, adverse effect on the organoleptic acceptability of the cooked meat. The ratings of the irradiated samples changed little over the duration of the experiment, while those for the non-irradiated samples became less favourable. As a consequence, after approximately 11 weeks' storage, the irradiated samples were preferred to the chilled control samples.

In considering the commercial application of the treatment, gains in storage life need to be balanced against losses in some quality attributes.

#### 4:6

##### INFLUENCE OF DIFFERENT CHILLING PROCEDURES ON THE EATING QUALITY OF PORK CHOPS

PATRICIA BARTON-GADE, CAMILLA BEJERHOLM and UFFE BORUP

Danish Meat Research Institute, Maglegårdsvej 2, DK 4000 Roskilde, Denmark

The effect of different chilling procedures on the eating quality of pork chops, in particular tenderness, was investigated on four factories. The chilling procedures varied from a mild traditional batch chilling to an extremely effective tunnel chilling. On each factory a number of pigs with a good water holding capacity (high or medium pH<sub>1</sub>-values) and different levels of intramuscular fat were chosen. The longissimus dorsi muscle was removed from each carcass the day after slaughter, divided into two portions (anterior and posterior), and each portion investigated for eating quality using a trained taste panel as well as relevant meat quality characteristics.

The results showed that cold-shortening occurred in the factory with the most effective chilling process. The average eating quality of the chops from this factory was unsatisfactory with 57% being designated as unacceptably tough.

The decrease in tenderness was especially great in pigs which were most susceptible to cold shortening i.e. pigs with high pH<sub>1</sub>-values, but it also occurred in the posterior portion of the loin in some of the pigs with medium pH<sub>1</sub>-values. Higher intramuscular fat levels could partially negate the effect of cold shortening.

The anterior portion of the loin was in general more tender than the posterior portion. pH<sub>1</sub>-values are however slightly lower in this region of the muscle and it is better protected against the effect of chilling.

Chilling conditions on the factory with best and poorest eating quality were in fact not that different. Process conditions should be arranged so that the time in the tunnel is not less than 60 minutes, if problems with cold shortening are to be avoided.

The factory with cold shortening has never received complaints about tough meat, probably as a result of the number of susceptible pigs (high/medium pH<sub>1</sub>-values) being rather low and the intramuscular fat level higher than on the other factories. The chilling conditions are now being adjusted on this factory, so that cold shortening does not occur.

#### 4:7

SOME MICROBIOLOGICAL AND CHEMICAL FEATURES OF THE BEEF PACKED IN OXYGEN+ CARBON DIOXIDE STORED AT 0°C

Fonseca, H.

INIA;ENTPA, Department of Technology of Animal Products. Veterinary High School. Rua Gomes Freire, 1199 LISBOA Codex PORTUGAL

Recent studies on atmosphere packing have dealt with changes in meat color, pH and/or microbial changes during storage as affected by gas composition. The aim of the present study was to compare the microbial and chemical changes on beef packed under a CO<sub>2</sub> atmosphere with those of beef packed under an air atmosphere.

The samples were obtained from Semitendinous and femoral biceps muscle steaks (1.5 cm in thickness) that were removed from beef carcass and divided into two equal groups (packaging treatments). All steaks were weighed and placed in polyethylene /polyamide bags. The bags were filled with about 2.4 l air (control) or 80% O<sub>2</sub> + 20% CO<sub>2</sub>. Steaks were stored at 0°C for specified storage periods (0, 3, 6, 9, 12, 15, 17, 20 and 22 days). Analyses of microbial

counts, percentage weight loss, pH, total basic nitrogen (T.B.N.), T.B.A. and percentages of myoglobin, metmyoglobin are performed in the storage periods.

The results obtained, concerning microbial count were higher in the steaks stored under air than those stored under 80% O<sub>2</sub> + 20% CO<sub>2</sub>. In all storage periods, the packaged steaks under controlled atmosphere exhibited higher weight losses than steaks packaged under an air atmosphere. A decrease in pH in the samples stored in Oxygen + Carbon Dioxide, was observed. The values of T.B.N. and T.B.A. as the values of metmyoglobin are lower in the steaks under controlled atmosphere.

Based on the results of this study, it appears that packaging beef under an 80% O<sub>2</sub> + 20% CO<sub>2</sub> atmosphere makes possible an extension in the shelf life of cold stored meat.

#### 4:8

'AIR TRAPPING' DURING VACUUM PACKAGING OF HOT AND COLD BONED BEEF

van Laack, H.L.J.M., Smulders, F.J.M. and van Logtestijn, G.L.

Department of the Science of Food of Animal Origin, Faculty of Veterinary Medicine, The University of Utrecht, P.O. Box 80.175, 3508 TD Utrecht The Netherlands.

Vacuum packaging at 99 % efficiency (10 mbar) results in more evaporation from hot than from cold meat. This causes the packaging film to become moistened, thus jeopardizing the sealability of the film and preventing adequate skinning. In addition, the surface of hot meat tends to be more sticky, resulting in 'air trapping' in the course of vacuum packaging. We examined the impact of such a deficient packaging technique on the composition of the trapped air and on the bacteriological condition of the packaged beef.

For this purpose, the left- and righthand side *M. longissimus dorsi* of two boner-grade Dutch Frisian cows were hot boned. The righthand side *longissimus* muscles were divided in 14, chops of approximately 200 gram each, which were immersed in a suspension of bacteria cultured from the scrapings of tables from a commercial beef cutting operation. After immersion chops were allowed to drain for ca. 10 s, whereafter the gained surface contamination was assessed by a destructive sampling method. After vacuum packaging 'air trapping' was simulated by injecting 8-10 ml of air through air-tight rubber discs which had previously been glued to the vacuum film. Before

refrigeration at 2°C, vacuum packs of righthand side *longissimus* were conditioned 5 h at 15°C. Except the conditioning period lefthand side *longissimus* muscles received a similar treatment after 24 h refrigeration at 2°C.

After 7, 14, 21 and 28 days of storage at 2°C the gas composition in vacuum packs of left- and righthand side chops was assessed by gas chromatography. Subsequently chops were unpacked and sampled for bacteriological examination.

The percentage of residual O<sub>2</sub> in vacuum packs subject to air trapping decreased faster in hot than in cold boned packs. The CO<sub>2</sub> content in vacuum packs of hot boned meat was consistently, 6-10 % higher than in cold boned counterparts throughout the entire sampling period. Aerobic Colony Count (TGBA, 3d, 30°C), Enterobacteriaceae Colony Counts (VRBC, 1d, 37°C), Gram-negative-/Pseudomonas Colony Counts (Gillenber, 3d, 25°C) and *Brochothrix thermosphacta* Colony Counts (STAA, 2d, 24°C) were also significant higher.

Possible mechanisms are discussed.

## WAY OF CUTTING BEEF SAMPLES AND ITS EFFECT ON LOSSES

LAURO MÜLLER

Departamento de Zootecnia, Universidade Federal de Santa Maria, 97119 Santa Maria, RS Brasil

A total of 135 samples from the Semitendinosus muscle of 15 steers with the weights of 8, 16, 24, 32 and 40 g but cut in different way, across or along the fibers, were utilized in this study to verify the effect of the way of cutting the muscle, across or along the fibers, on losses. The samples were weighed, wrapped in polyethylene and frozen at - 20 C for one week. Samples were thawed overnight (18 hs) at about 7 C. They were then removed from the plastic film, dried with tissue paper and weighed to determine drip loss. Samples were cooked in a water bath at 70 C for 30 minutes, then dried and weighed again to determine cooking loss. Samples cut across fibers presented an average drip loss of 5.5%, cooking loss of 32% and total loss of 36%. Samples of the same weight but cut along the fibers presented

3, 28 and 31% for drip, cooking and total loss, respectively. The step equations showed that the weight of the sample was the major variable affecting the weight of losses. Higher losses were obtained in heavier samples. The weight of the sample however did not significantly affect the percentage of losses. This parameter was highly influenced by the size of the area cut across fibers. By increasing the area in samples of same weight, there was a rise in the % of losses.

It can be concluded that, in order to reduce losses in moisture, it is of paramount importance to minimize the area cut across fibers.

## PULSED CUTTING OF BRITTLE BIOMATERIALS

V.I. IVASHOV, V.A. ANDREENKOV\*, S.G. YURKOV\*\*, B.N. DUJDENKO\*\*, V.A. ONIZHENKO\*\* and M.M. AKIMOV\*\*

\*The All-Union Meat Research and Designing Institute, Moscow, USSR  
\*\*The Moscow Technological Institute of Meat and Dairy Industries, Moscow, USSR

High rate of pulsed cutting is connected with a high rate of materials deformation. At high rate cutting diagrams of cutting and physico-chemical properties of brittle biomaterials differ from diagrams of cutting and materials properties that are characteristics for low rate processing ( up to 1m/s).

To study pulsed cutting diagrams an experiment was made on a test rig. The latter consisted of pendulumic pile driver, accelerated filming apparatus and measuring station with accelerated oscillograph. It is found that the process of brittle biomaterials pulsed cutting may be divided into several stages: 1st - accumulation of destroying stresses; 2nd - formation of microcracks while a knife is being inserted into the depth of 0.05-0.1 relatively to samples thickness; 3rd - formation of an advanced crack while the sample is being destroyed to a degree that equals to the value of knife penetration and of an advanced crack. At the latter stage sample is fully parted. This occurs when external energy ( $E_e$ ) and potential energy ( $E_p$ ) of elastic deformation, that is separated at destruction, are greater than total energy of interatomic connections ( $E_A$ ) along the whole trajectory of cutting. If the crack is being stopped in the sample, than  $E_e + E_p \leq E_A$ . To finish the work of cutting forces it is necessary to use a complementary external energy. Sample condition at  $E_e + E_p = E_A$  is called an equilibrium, and at  $E_e + E_p > E_A$  - stationary. At pulsed cutting of biomaterials

is there occurs one, two or more equilibrium-stationary conditions; in these cases growth of advanced cracks slows down and shear force changes.

The rate of longitudinal waves ( $a_0$ ) distribution and dynamic modulus of elasticity ( $E_{din}$ ) were determined experimentally using the ultrasound method on the samples of compact bone tissue extracted from various sections of cattle tubular bones. For this purpose diaphysis was conventionally divided into 5 zones, of  $3.5 \times 10^{-2}$  m each, starting from proximal epiphysis. Nine samples of cylindrical form ( $d = 5 \times 10^{-2}$  m,  $h = (6.0-12.0) \times 10^{-2}$  m) were taken from each zone, by three samples from lateral, caudal and medial areas of bone cross-section. Samples were made according to the three mutually perpendicular directions.

The rate of ultrasound longitudinal waves ( $a_0$ ) distribution in samples was measured using the apparatus DUK-20 at frequency being equal to 150kHz.

Dynamic modulus of elasticity ( $E_{din}$ ) was determined by the ratio:  $E_{din} = \rho \times a_0^2$ , where  $a_0$  - rate of ultrasound longitudinal waves, m/s;  
 $\rho$  - bone density,  $kg/m^3$ .

Based on calculations average values of dynamic modulus of elasticity  $E_{din}$  are obtained; according to these values it is possible to conclude that modulus of elasticity has its maximum level in medial section of diaphysis at longitudinal direction, and minimum - in tangential and radial directions. In zones adhering to epiphysis there is a tendency to convergence of dynamic modulus of elasticity at all directions, i.e. compact bone tissue in these areas is a material with insignificant degree of anisotropy!

FOR SCHEDULE REASONS,  
REVISION NOT COMPLETED

## EFFECTS OF SODIUM CHLORIDE ON THE HYDRATION OF FRESH AND FROZEN-THAWED PSE PORCINE MUSCLE

Severini, M., Vizzani, A. and Cenci, G.

Istituto di Ispezione degli Alimenti di Origine Animale, Facoltà di Veterinaria, Università di Perugia

Via San Costanzo 06100 Perugia, Italia

PSE swine muscle shows a greater swelling capacity than normal muscle. Sodium chloride affects the hydration of muscle and plays an important role in the processing of meat.

In the present study the effects of high sodium chloride concentrations on the hydration of fresh and frozen-thawed PSE porcine Longissimus dorsi muscle after wet curing and a short drying period have been investigated.

Slices taken from normal and PSE L. dorsi muscles 24hr after slaughter were immersed in brines with 10%, 15% and 20% NaCl. Slices taken within 2hr after death were fast frozen, stored for 7 days, then thawed (24hr at 4°C) and immersed in brine with 10% NaCl. All slices were allowed to drip for 4 days and dried for 2 or 7 days at a controlled temperature and humidity.

Normal and PSE muscles showed very similar pH and WHC values at 24hr post mortem. Slices from PSE muscles showed greater weight gain in any given condition, but only slight differences were observed after curing with 20% NaCl.

At 10% and 15% salt concentrations the PSE muscles absorbed more water and salt than normal. At a 20% NaCl concentration they were less dehydrated and took up more salt. The earlier onset of rigor mortis seems to be the cause of the greater swelling of PSE muscle. However, the percentages of nitrogenous material were slightly higher in brines used for PSE muscles than in those used for normal muscles. The differences in weight gain between fresh normal and PSE muscles were remarkably reduced when weight loss during storage was taken into account.

This might imply that the hydration capacity of the muscles at 24hr post mortem is somewhat related to the factors affecting the drip loss.

The freezing-thawing process increased the swelling capacity expressed as weight after curing/weight before curing and humidity/protein. However, PSE muscles showed a lower weight gain expressed as weight after curing/weight before freezing. This could be due to the massive drip loss, and thus loss of nitrogenous material during the thawing. The ratio humidity/protein in the normal and PSE muscle likewise decreased during the dripping and drying period. This means that the NaCl concentration will increase further when the humidity/protein ratio in PSE muscle reaches the same value as in normal muscle.