ELECTRON MICROSCOPIC STUDY OF TUMBLED PORK AND TURKEY MEAT, PRODUCED WITH OR WITHOUT PHOSPHATE

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Background & Objectives

The addition of phosphates to meat products has a quality maintaining or improving effect. The final quality of meat is dependent on various conditions. By using a combination of phosphates of different chain lengths and pH values optimal results can be achieved for meat products. Especially diphosphates have a highly specific effect on the water holding capacity of muscle proteins. They have similar properties as adenosine triphosphate (ATP) in the living organism, because they recover the natural water holding capacity to a great extent of the actomyosin complex (Schnee, 1998). The effect of phosphates in meat is well known. The literature, however, does not give any electron micrographical figures showing the effect of phosphates in meat.

This study was designed to fill that gap with special focus on the synergistic effect of phosphates and salt.

Materials & Methods

In this study fresh pork from the overhead panel and turkey breast were examined. The meat samples were cleaned from connective tissue and thin stripes were cut transverse to the fibre course. The striped meat samples were tumbled in brine at –2°C and 0.6 bar for 5 minutes.

The diphosphates (pyrophosphates) used were obtained from Chemische Fabrik Budenheim (Budenheim/ Germany) and BK Giulini Chemie GmbH & Co. OHG (Ladenburg/ Germany). Tetrapotassium pyrophosphate (TKPP; E 450; pH 10.3) and a phosphate mixture (E 450; pH 7.3) consisting of TKPP and sodium acid pyrophosphate (SAPP) were used in a 60 : 40 ratio. The samples were exposed to 0.3 % phosphate solutions in combination with 1.6 % salt. Additionally, two other investigation series were performed using only 1.6 % salt or 0.3 % TKPP, respectively.

Scanning electron (REM) and transmission electron microscopic (TEM) methods were applied. Tissue samples, 10x10x10 mm in size, were taken for each investigation series. Demonstration of surface structures with a resolution of up to 5-10 nm was possible by REM. With TEM, ultrastructural changes in the muscle tissue were examined, achieving resolutions of atomic dimensions (0.1 nm).

Results and Discussion

Figure 1a shows muscle cells of untreated pork with no textural alterations. In Figure 1b relaxed sarcomeres are shown displaying the typical order of bands.

In salt-treated meat (Fig. 2a and b, REM), the muscle cells are swollen and evenly covered by fragments of myofibrils and connective tissue. Swollen, shortened, and disintegrating sarcomeres are visible (Fig. 2c, TEM). The shortening of the sarcomeres averages 24 % and due to swelling they expand in width by about 15 %. Thus, the actin filaments move closer towards the A band, disconnecting from their anchoring Z lines, and finally creating 3-dimensional networks (Fig. 2d, TEM). Actin filaments transform into flaky, swollen structures, stabilised by nail-shaped myosin fragments.

Figure 3 shows REM micrographs of pork treated with TKPP/SAPP and salt, respectively. Here, the swelling of the muscle cells is very specific and they show superficial fissuring.

Shortening, but not swelling of the disintegrating sarcomeres can be detected by ultrastructural investigation (Fig. 4). Due to the shortening, the typical band structure is lost. With increasing length of exposure the structures relax slightly and the formation of 3d networks increases.

In the samples treated with TKPP and salt the muscle cells are swollen and tightly arranged (Fig. 5). Some fragments swell, linking together to form a uniform layer that covers the surface entirely.

After phosphate treatment, shortening of the sarcomeres up to about 40 % and expansion in width by about 45 % was observed in ultrastructural examination (Fig.6). As a result the intrafibrillar interval is increased and therefore more water can be bound.

In the samples exclusively treated with phosphate (TKPP, Fig. 7) the muscle cells show irregular spaces in REM-examination. The surface is completely covered by fragments of muscle cells and myofibrils. In ultrastructural observation, the relaxed sarcomeres are in the process of disintegration and form areas of debris. The effect of swelling was not found in ultrastructural examination of samples exclusively treated with TKPP. The volume of the sarcomeres resemble that in untreated meat.

Conclusions

- Only the combination of salt and phosphate leads to the „desired swelling" of muscle cells in treated meat; also, the water holding capacity is better, leading to greater tenderness (synergistic action).
- Phosphate greatly effects the degradation and loosening of the muscle texture and the separation of the acto-myosin complex. As a result fine fragments of myofibrils are formed, but no gels are created.
- Salt, by itself, leads to the loosening of the transversal structural elements (M line and Z band). Chloride ions and fibrillar muscle protein are linked together, therefore producing electrostatic forces that lead to the expansion of the interfilamentary spaces. Those additional translucent spaces benefit the linkage or storage of water.
- The different effects of the phosphates used in this investigation were mainly due to the different pH values applied.

References

Schnee, R. (1998): Phosphates for food processing. Sonderdruck der Chemischen Fabrik Budenheim. Budenheim/ Germany.

Stolpe, S. (2003): Elektronenmikroskopische Untersuchungen an getumbeltem Schweine- und Putenfleisch, hergestellt mit und ohne Phosphat. Technische Fachhochschule Berlin/ Germany. Diplomarbeit.

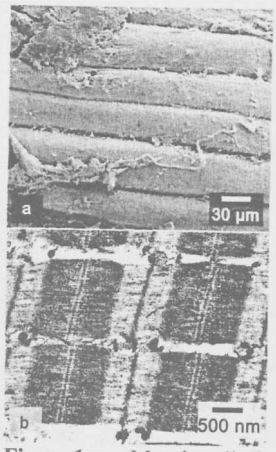

Figure 1: -a: Muscle cells from untreated pork (REM). **-b:** Myofibrils from untreated turkey (TEM).

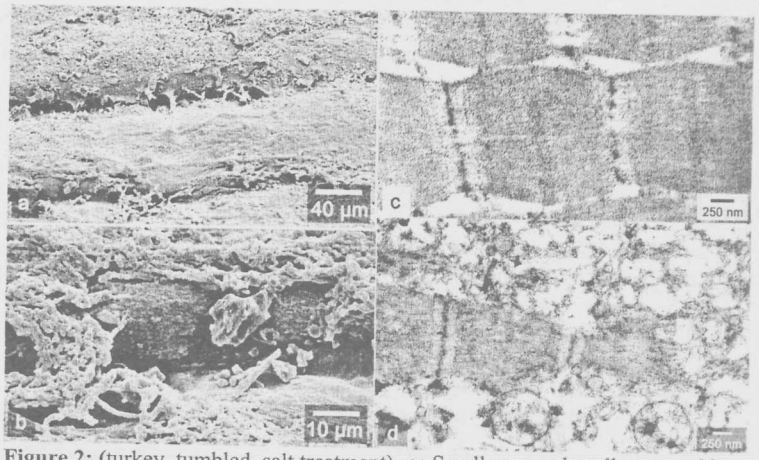

Figure 2: (turkey, tumbled, salt treatment) **-a:** Swollen muscle cells covered by a layer of **-b:** fragments of swollen myofibrils (REM). **-c:** Shortened and swollen sarcomeres with longitudinal spaces (pork, TEM). **-d:** Formation of a 3-dimensional network (pork, TEM).

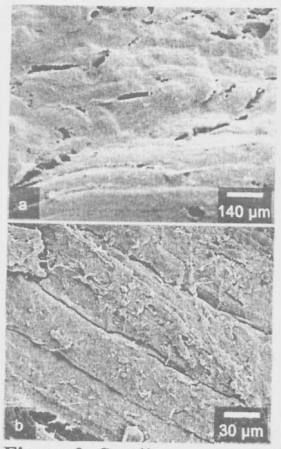

Figure 3: Swollen muscle cells (pork, tumbled, salt and phosphate treatment, TKPP/SAPP). **-a**: The surface of the muscle cell is plane and fissured. The muscle cells are covered by fragments of swollen muscle cells. **-b**: The surface is porous and rough. Single swollen muscle cells are recognisable (pork, REM).

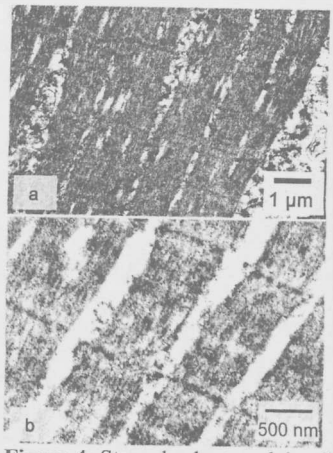

Figure 4: Strongly shortened, hardly swollen muscle cells with signs of disintegration in the area of the A band (tumbled, salt and phosphate treatment, TKPP/SAPP)
-a: (turkey, TEM)
-b: (pork, TEM).

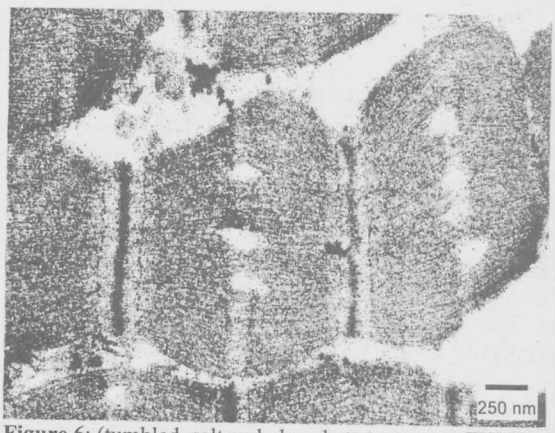

Figure 6: (tumbled, salt and phosphate treatment, TKPP) Strongly swollen sarcomeres, esp. obvious in the H band region, where they also show signs of disintegration (turkey, TEM).

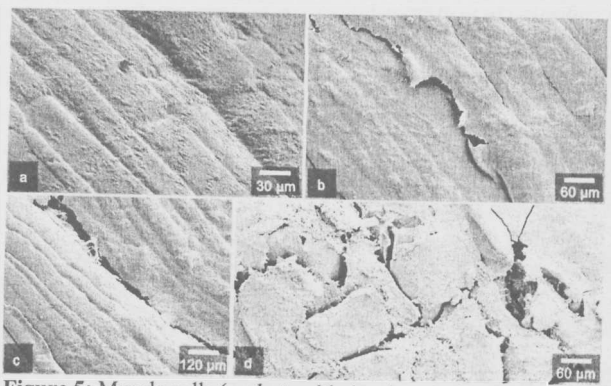

Figure 5: Muscle cells (pork, tumbled, salt and phosphate treatment, TKPP). **-a**: Swollen muscle cells with regular spaces. **-b/-c:** The muscle cells are swollen to such a degree that large superficial fissures, extending across the entire sample are formed. **-d:** When swollen, the myofibrils form a unit, therefore no single myofibrils can be seen in the cross section (REM).

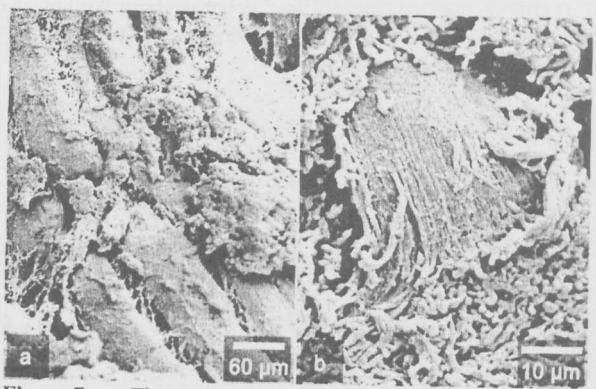

Figure 7: -a: The surface is covered by fragments. Often fractures can be seen, contributing to the strong loosening (pork, tumbled, phosphate, TKPP). **-b**: Disintegration of muscle cells. The myofibrils break into many fine fragments and cover the surface of the muscle cell (REM, turkey, tumbled, phosphate, TKPP).