# Studies on Some Market Meats in Egypt. II. Histological Characteristics as Influenced by Aging, Freezing and Storage

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## ABSTRACT

Histological changes in muscle tissue structure in three kinds of meat were followed during storage at 40°F and during storage in the frozen state at 14°F. Microscopic examination of sections obtained from the Longissimus dorsi of buffalo veal, beef and camel was carried out at different intervals for both aged and frozen meat samples. Number and dimensions of fibers and sarcomeres were determined. The shape of tissue fibres and number of cell nuclei were observed for both technological treatments carried out on the three kinds of meat.

## INTRODUCTION

The chemical and biochemical changes occurring in muscle tissue of animal carcasses before, during and following the resolution of rigor mortis attracted the attention of many investigators during the last decade (1,3,11,15,18,20). Extensive studies were also carried out on the effects of many technological processes on the different characteristics of meats with special emphasis on their palatability (2,8,9,11,19). In addition, attempts were made to follow physical changes taking place in muscle tissue structure during meat preparation, handling and preservation through microscopic examination (2,4,7,8,9,10, 18).

A muscle fibre is a cell of 10 to 100 microns in length filled with myofibrils of about one micron in thickness and containing a number of nuclei and mitochondria. The myofibrils are divided into sub-units known by sarcomeres. The sarcomere (2-3 microns in length), contains a central dark zone named A-disc surrounded by two light zones known by I-discs. In the middle of each I-disc there is a dark Z-band. The sarcomere was considered to be the zone located between two Z-bands. Appearance of the different bands and zones in microscopic examination depends on the state of contraction or relaxation of muscles (17).

It was found by Lowe (12), that shape and muscle fibre dimensions changed during

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rigor mortis. Toughness of meat was correlated with such changes taking place while the muscle was contracted during rigor. Following the resolution of rigor mortis the endomysium exhibited varying degrees of degradation while the perimysium appeared deformed in different shapes (18).

Chemical changes occurring in muscle tissues obtained from three kinds of meat during storage under different conditions were reported by the authors (6). It was felt necessary to extend the study to examine histologically changes in muscle cell structure taking place during aging as well as during storage in the frozen state of buffalo veal, beef and camel meat.

## MATERIAL AND METHODS

### Meat Samples

Buffalo veal, beef and camel meat samples used in this study were prepared and stored according to the techniques described in a previous study (6). Microscopic sections were prepared for histological studies at different intervals.

### Preparation of Meat Sections

The technique described by Carleton and Short (5), was followed in the preparation of meat microscopic sections. Weigert's iron hematoxylin stain and Van Greison's stain were used for identifying different muscle cell structures. Five micron thick sections were prepared using a sliding microtome (B.M.S. — 66483/Germany). Sections were photographed with various enlargements which ranged from 80 × up to 480 ×.

## RESULTS AND DISCUSSION

Generally, all longitudinal sections prepared from the Longissimus dorsi muscles of freshly slaughtered buffalo veal, beef and camel showed either straightened or slightly wavy shaped fibres. However, fibres of camel meat sections appeared more wavy compared to those of veal and beef. In the cross-sections of meat samples there was more noticeable interspaces between fibres of camel tissues, while they were not evident in both veal and beef tissues. Neither rupture nor destruction of fibres or nuclei were observed.

Data presented in Table 1, showed that buffalo veal muscle tissue had the least fibre thickness compared to both beef and camel tissue, prepared from freshly dressed carcasses. Camel tissue fibres had slightly thicker fibres than those of beef. Undoubtedly, some of these differences are due to age of animals with buffalo veal being significantly younger than either beef or camel. Tinikov (18), reported an increase in fibre diameter with increase in animal age without any change in their number.

The number of fibres in cross-sections of meat tissues per microscopic field as estimated in consecutive section per sample was 17, 9 and 8 for buffalo veal, beef and camel meat, respectively. With respect to the length of the sarcomeres, results obtained showed average values of 2.9–3.2 microns for buffalo veal, 2.2–2.9 microns for beef and 2.0–3.6 microns for camel meat (Table 2). The number of nuclei per standardized microscopic field (480 ×) averaged 193 for buffalo veal, 100 for beef and 84 for camel muscle tissue. Although the average number of nuclei per microscopic field appeared to be highly significant among the three kinds of meat, the average number per fibre were almost the same.

The effects of meat aging process on the muscle structure were studied on meat samples held at 40°F for a maximum period of 15 days. At the start of the histological examination, samples were withdrawn at short intervals as shown in Tables 1 and 2. This was deemed

Table 1 Effect of aging at 40°F on fiber diameter and their number per unit microscopic field, in samples of muscle tissues from buffalo veal, beef and camel.

| | Kind of Meat | | | | | |
|---|---|---|---|---|---|---|
| | Buffalo veal | | Beef | | Camel | |
| Storage Period | No. fibers | Diameter (micron) | No. fibers | Diameter (micron) | No. fibers | Diameter (micron) |
| 0 | 17 | 7.7–34.7 | 9 | 11.6–61.6 | 8 | 15.4–69.0 |
| 9 hr | 12 | 11.6–53.9 | 7 | 27.0–100.0 | 6 | 15.4–77.0 |
| 1 day | 15 | 11.5–46.2 | 5 | 30.8–107.8 | 5 | 30.8–77.0 |
| 2 days | 16 | 7.7–42.4 | 5 | 30.8–107.8 | 5 | 30.8–77.0 |
| 3 days | 11 | 7.7–30.8 | 6 | 19.3–69.3 | 4 | 39.0–127.5 |
| 6 days | 20 | 7.7–23.1 | 8 | 15.4–69.3 | 6 | 30.8–92.4 |
| 15 days | 20 | 7.7–23.1 | 11 | 15.4–65.5 | 8 | 15.4–84.7 |

Table 2 Effect of aging at 40°F on sarcomere length and their number per centimeter, in samples of muscle tissue from buffalo veal, beef and camel.

| | Kind of Meat | | | | | |
|---|---|---|---|---|---|---|
| | Buffalo veal | | Beef | | Camel | |
| Storage Period | Number of sarcomeres | Length (micron) | Number of sarcomeres | Length (micron) | Number of sarcomeres | Length (micron) |
| 0 | 9–10 | 2.9–3.2 | 10–13 | 2.2–2.9 | 8–14 | 2.0–3.6 |
| 9 hr | 12–14 | 2.0–2.4 | 14–18 | 1.6–2.0 | 14–16 | 1.8–2.0 |
| 1 day | 11–14 | 2.0–2.6 | 16–18 | 1.6–1.8 | 18–20 | 1.4–1.6 |
| 2 days | 11–14 | 2.0–2.6 | 16–19 | 1.5–1.8 | 19–20 | 1.4–1.5 |
| 3 days | 11–12 | 2.4–2.6 | 12–13 | 2.2–2.4 | 18–20 | 1.2–1.6 |
| 6 days | 11–12 | 2.4–2.6 | 12–13 | 2.2–2.4 | 8–19 | 1.5–1.6 |
| 15 days | 11–12 | 2.5–2.6 | 11–13 | 2.2–2.6 | 8–20 | 1.4–1.6 |

necessary since no information was available in the literature regarding time elapsed after animal death till rigor mortis sets in, its duration and its resolution in buffalo veal.

Data obtained indicated that 9 hours after the start of the aging process buffalo veal tissue showed clear undulated and deformed muscle fibres while no intensive wavy fibres were observed in both beef and camel tissues. Such changes were generally associated with alterations in the dimensions and numbers of both fibres and sarcomeres (Tables 1 and 2). No changes were observed in the number or shape of fibre nuclei or nucleates. In the cross-sections of buffalo veal tissue the interspaces between fibres were quite noticeable. This was not true in the case of beef or camel tissue.

Samples examined after 24 hours of aging showed that veal tissue fibres appeared more straightened with very few remaining undulated. The sarcomeres became somewhat longer while fibre diameter appeared narrower. In addition, the interspaces between fibres became less clear. In both beef and camel muscle sections, there were more wavy fibres compared to sections prepared at the 9 hour interval. Length of sarcomeres in beef tissues decreased in length to about 66.7% of that in the fresh tissue. Similar observations were made in camel tissue with decrease in sarcomere length to about 53.9% of that in the fresh tissue. Such a difference between beef and camel tissues may be explained by the fact that camel meat was still in rigor while beef was in the process of resolution. Chemical analysis reported by the same authors (6), for the same samples confirmed such observations.

Sections prepared from samples aged for 48 hours at 40°F showed that buffalo veal exhibited strong evidence resolution. Meanwhile, beef and camel meat still showed signs of contracted fibres in addition to some short sarcomeres indicating different stages of the state of rigor mortis.

After 3 days of aging buffalo veal tissues showed complete resolution of rigor mortis as indicated by disappearance of wavy fibres, increase in the length of sarcomeres and appreciable decrease in fibre thickness (Tables 1 and 2). Signs of rigor resolution were evident in beef tissues as determined by both fibre thickness and sarcomere length and numbers. However, there were still some wavy fibres detectable in tissue sections indicating that resolution of rigor mortis at this interval was not complete. On the other hand, camel meat sections showed highly undulated and wavy fibres, still in a contracted state and indicating that rigor mortis was still in progress. These observations were still evident for camel meat at the 6th day of aging. Meanwhile, buffalo veal tissue showed signs of degradation and autolysis by the disappearance of cross-striation and some nucleates. In addition, beef tissues exhibited almost straight and narrower fibres and sarcomeres with no signs of biochemical degradation of tissues at the 6th day of aging. Definite signs of complete resolution of rigor mortis in camel meat tissue did not appear until the 15th day of aging. Meanwhile, both buffalo veal and beef tissues showed varying degrees of biochemical degradation detected by histological examination and confirmed by chemical analysis as reported in an earlier paper for the same authors (6).

Since the freezing process used in this study was undoubtedly slow (14°F), first samples drawn were after 48 hours for buffalo veal and 72 hours for beef and camel meat. Generally, tissue sections prepared for all three kinds of meat withdrawn at different freezing storage intervals and up to 15 days showed consistent decrease in number of fibres per microscopic field with almost no change in fibre diameter. On the other hand, the trend was towards an increase in the number of sarcomeres per unit length as well as a decrease in sarcomere length in all three kinds of meat as the storage period increased. The intercellular spaces showed wide variations between kinds of meat studied with camel meat exhibiting the least amount of intercellular spaces. The above observations reflected the differential influences of slow freezing on the physical characteristics of muscle tissue as affected by ice crystal formation which in turn is dependent on both muscle moisture content and its water binding capacity. In addition, some biochemical changes would be anticipated, with varying degrees according to the kind of meat, until the meat samples were frozen solid as well as during the thawing process.

In conclusion, it is clear that differences observed among the three kinds of meat aged at 40°F are due to species and age differences at the time of slaughter. Buffalo veal is usually slaughtered at a significantly younger age (4–10 weeks) compared to beef (1–2 years) and camel (8–12 months). Buffalo veal exhibited histological characteristics of rigor mortis and its resolution much earlier than either beef or camel meat. On the other hand, camel meat was the latest to show occurrence of rigor with a much longer duration compared to the two other kinds of meat although camels are slaughtered at a younger age than beef. Histological observations made in this study were in agreement with the chemical changes associated with incidence of rigor mortis and its resolution with special reference to total soluble nitrogen, protein and non-protein soluble fractions in muscle tissues (6).

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