NORTHERN AUSTRALIAN SHARK
Avoiding tough flesh

By Steven Slattery [1]

Abstract
The texture of two species of northern Australian shark is mainly effected by the biology of the fish. One species, *Carcharhinus sorrah*, requires higher energy to shear a sample of its cooked flesh than does the other, *C. tilstoni*. Male shark are firmer than females and shark with a fork length larger than 85 cm were tough. Of the combination of sex and species group, only male *C. sorrah* were tough. Further definition of groupings also identified female *C. sorrah* larger than 85 cm fork length and male *C .tilstoni* larger than 85 cm fork length as being tough. A manual of best practice was drawn up from the results of a range of experiments.

Best practice recommended for processing shark was:
1. kill, bleed and gut immediately after catch
2. keep trunks cool until rigor has set, but not longer
3. store trunks in refrigerated seawater (RSW) for up to 12 hours
4. then freeze trunks or fillets
5. shark should not be frozen prerigor or kept on deck till postrigor.

Keywords: Shark; *Carcharhinus sorrah; Carcharhinus tilstoni;* Flesh; Texture difference; Biological causes; Processing; K-value.

Fillets from two commercial species of shark caught in northern Australian waters, the school or sorrah shark (*Carcharinus sorrah*) and the black spot or black tip shark (C. *tilstoni*) have been found to suffer from textural problems. Shark fillets which are tough after cooking have been identified in shipments originating both from northern and overseas suppliers. The occurrence has been random and the cause difficult to identify. A research project (93/190) was funded by the Fisheries Research and Development Corporation (FRDC) to investigate the problem. As a result of the investigations a manual of best practice has been written which reports the causes of toughness and how tough flesh can be avoided. The manual is reproduced in modified form for these proceedings. A total of 529 shark samples were tested and analysed for differences in texture between season, species, sex, size and rigor stage.

TESTING FOR TEXTURE
The texture of food can be analysed mechanically using an instrument called an Instron Universal Testing Machine. This machine can mimic the action of a bite by a consumer. A piece of fillet is cut by metal blades and the machine measures the amount of resistance there is to cutting. The measurement is called the 'shear force energy'.

The shear force energy of tough shark was almost twice that of soft shark in samples submitted as being tough or soft by industry (Figure 1). The value of 0.435 J for shear force energy was then used as an industry standard and any shark with a shear force energy equal to, or higher than, this value can be said to be tough.

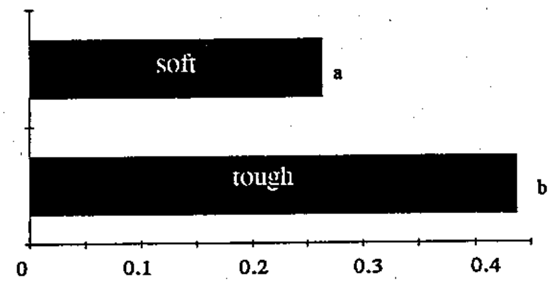

Figure 1: Energy required to shear cooked samples of commercial shark designated as being tough or soft by industry. There is a significant difference between values ($P<0.01$)

TEXTURE DIFFERENCES
Each species of fish and shark has its own individual textures and flavours. Sometimes these can be quite different from other closely related

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species. Warm-water species of shark have been found to be more coloured, firmer and meaty in texture and tangy in flavour when compared with cold-water species which were whiter, softer and blander. Each consumer has individual preferences for different traits and only when some become extreme does everyone agree that the sample should be rejected.

BIOLOGICAL CAUSES

Often fish with poor texture or taste have been called "mother-in-law" fish and these usually fetch low prices when marketed. The mangrove shark (*C. cautus*) has already been found to have poor consumer acceptability because of dry rubbery texture. The two shark species discussed here have different textures. Overall, the fillets from the sorrah shark (*C. sorrah*) require 25% more energy to shear than fillets from the black spot shark (*C. tilstoni*) (Figure 2) This means that, in general, sorrah shark (*C. sorrah*) are tougher than *C. tilstoni*.

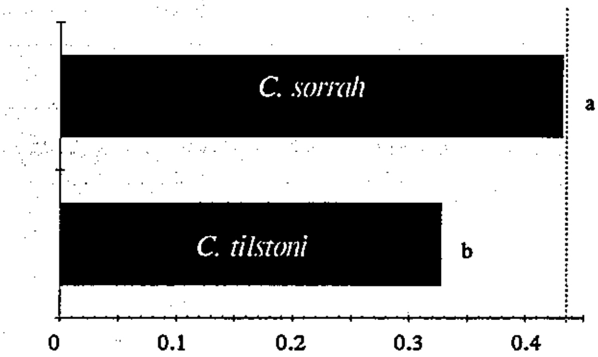

Figure 2: Energy required to shear cooked samples of two species of shark. There is a significant difference between values ($P<0.01$)

This textural difference is mainly controlled by biological characteristics. Knowing how these shark grow and breed will help understand why tough texture develops.

Sex

Differences in texture can be due to the sex of an individual. These two shark species give birth to live young. The females mate in February and March and ovulation occurs by March-April. The embryos are retained in the uterus and the yolk sac forms a sort of "yolk placenta". As the yolk is used up the relationship between the embryo and mother's tissues becomes complex and close and the young are nourished by the food in the mother's blood in a similar way to mammals. The gestation time is lengthy, taking up to a year before the young are born. The young shark are quite large at birth with *C. sorrah* around 52 cm total length while *C. tilstoni* average 60 cm. The litter size increases with the size of the mother.

This type of reproduction places considerable nutritional strain on females during the maternity period and in times of starvation they use their own body tissue to feed the young. The males do not suffer as much during these times and so are in better condition with the protein component correspondingly firmer. Texture can differ between the sexes (see Figure 3). The average level of shear force energy for all the males in the catch was much higher than the females. This means males are generally tougher and the value is close to the level of the tough samples obtained from industry.

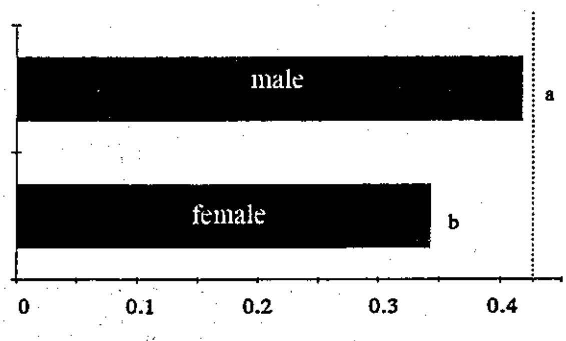

Figure 3: Energy required to shear cooked samples of male and female shark of both species (*C. sorrah* and *C. tilstoni*). There is a significant difference between values ($P<0.01$).

Size

As an animal grows, its muscle also becomes tougher in texture. The much greater toughness of meat from an old bullock in comparison to veal is a good example of this. The same occurs with shark (see Figure 4). Shark with a fork length greater than 85cm are tough (this is equal to a shark with a total length of one metre).

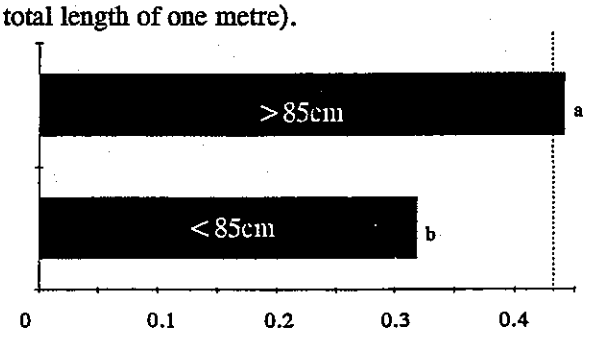

Figure 4: Energy required to shear cooked samples of shark of two different size groups of both species (*C. sorrah* and *C. tilstoni*). There is a significant difference between values ($P<0.01$).

Growth rate can slow during the life of an animal so that as an individual matures the amount it increases in length each year becomes smaller. Large individuals that are longer by only a few centimeters can often be several years older than those which are small.

Sex and size

When two aspects which are known to affect texture, such as sex and size, are studied together then the main causes of tough fillets starts to become identifiable. Male shark larger than 85 cm fork length can be seen as the main source of toughness so these should be rejected (see Figure 5).

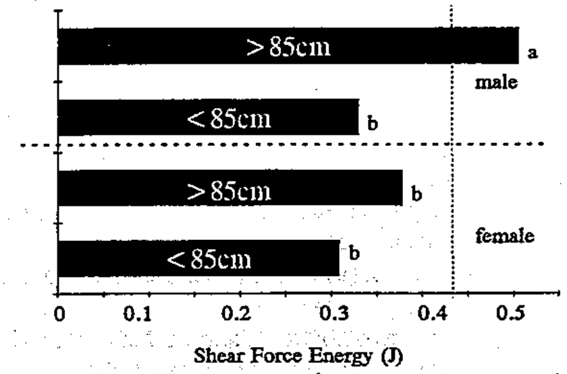

Figure 5: Energy required to shear cooked samples of male and female shark of two different size groups of both species *(C. sorrah* and *C. tilstoni)*. Means followed by a similar letter are not significantly different (P>0.01).

Species and sex

When the effects of species and sex are examined it is obvious that the male sorrah is the main source of tough fillets (see Figure 6). The average texture from a catch of male *C. sorrah* is much higher than the industry rejection level.

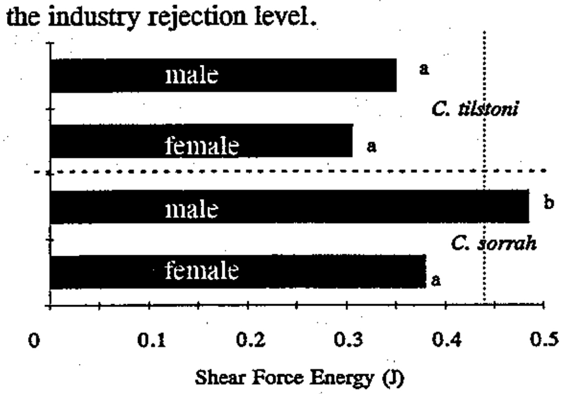

Figure 6: Energy required to shear cooked samples of male and female shark of two different species *(C. sorrah* and *C. tilstoni)*. Means followed by a similar letter are not significantly different (P>0.01).

Thus, help reduce the incidence of tough shark male sorrah (*C. sorrah*) should be separated from the catch and only be processed for purposes which will allow for this toughness.

The separation of the catch into all the possible groups, while identifying the groups responsible, can be misleading because of uneven sample size. The average texture of male sorrah less than 85cm is close to the industry samples of tough shark which means that while there are some tender individuals just as many are tough. As indicated earlier all sorrah males as well as sorrah females and tilstoni males larger than 85cm fork length should be rejected. the n in the graph refers to the number of shark assayed.

PROCESSING FOR THE BEST QUALITY

A number of on-deck aspects were investigated - season of capture, the biological features, the rigor stage when placed in RSW, the temperature of the RSW and the storage period.

The quality attributes of seafood deteriorate with period of storage and elevated temperatures. One chemical measure of this change is the K-value.

The K-value is calculated from the breakdown of ATP, a chemical which is needed for the muscles to work. This method is also used to identify frozen fish which may be submitted illegally during fishing competitions.

When an animal dies the ATP in the muscle begins to break down as rigor mortis commences and K-value increases as rigor progresses (see Figure 7).

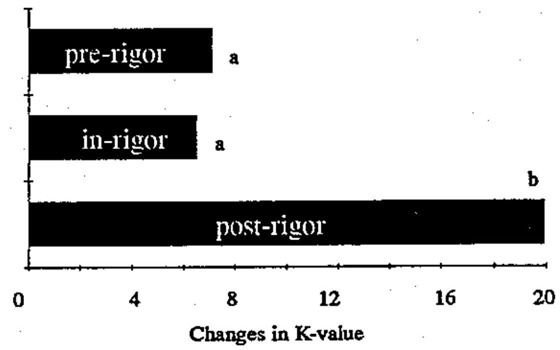

Figure 7: K-values of raw flesh of shark from all sizes, species and sex due to handling and storage at different stages of rigor. Means followed by a similar letter are not significantly different (P>0.01).

It is obviously important to process a catch as quickly as possible but problems of tough texture can occur if a fillet is frozen before rigor develops since the rigor process will occur when the trunk is thawed. This toughening is called thaw rigor. It is known that cold water species of shark need to be kept until the trunks are stiff with rigor before fillets can be cut. In the project shark landed live and killed immediately took from 30 min to 8 h to enter rigor regardless of species or sex.

Another form of toughening can develop because shark or fish are kept at too high temperatures such as being left on deck until rigor subsides before freezing. The deterioration of the flesh leads to the production of formaldehyde during frozen storage. This chemical hardens the protein in the flesh.

The worse the conditions the carcase is kept in, the quicker the K-value increases.

The season can have an impact due to water and deck temperatures as shown in Figure 8.

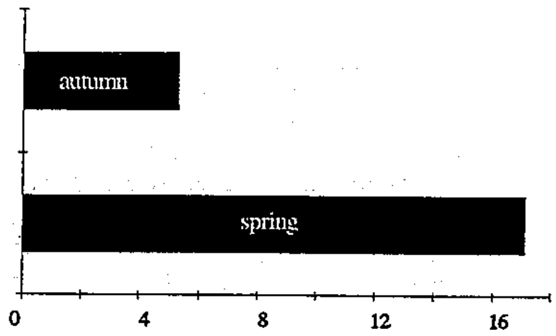

Figure 8: K-values in raw flesh of shark from all treatments (species, sex, size) held in RSW at two different seasons.

During spring and summer temperatures of the water (and on deck) will be higher than in autumn and winter and if shark are not looked after K-values will increase rapidly.

To slow down this increase in K-value, seafood should be chilled quickly and kept at low temperatures if it cannot be frozen straight away.

Storage in RSW is a quick way of reducing core temperatures (see Figure 9).

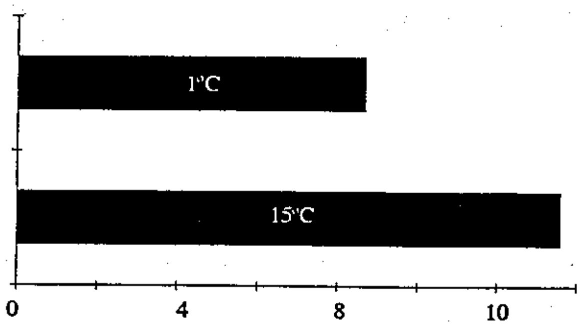

Figure 9: K-values in raw flesh of shark for all treatments (species, sex, size) held in RSW at different temperatures.

When the change in K-value for all of these handling aspects is studied in combination, as seen in the Figures 10 and 11, the best and worst practices can be identified. The worst way to process shark is to keep trunks on deck until postrigor and then store in RSW at 15°C, especially during the spring and summer.

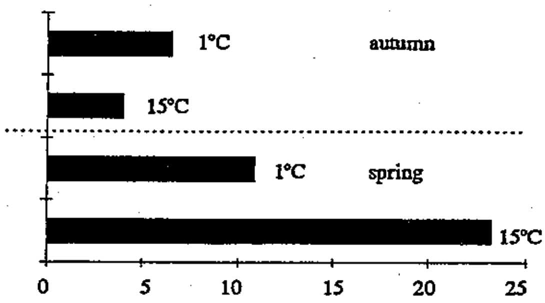

Figure 10: K-values in raw flesh of shark of all treatments (species, sex, size) stored in RSW at two different temperatures over two seasons.

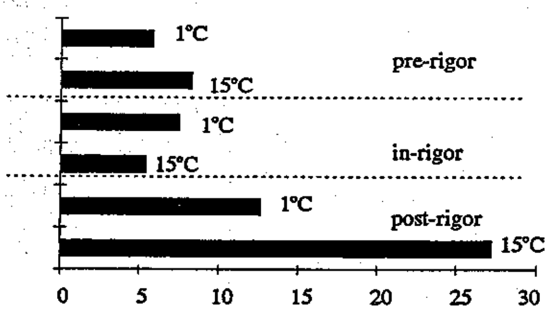

Figure 11: K-values in raw flesh of shark of all treatments (species, size, sex) stored in RSW at two different temperatures at different stages of rigor.

CONCLUSION

The best way to process northern shark is to:

1. kill, bleed and gut immediately;

2. keep the trunks in running seawater until rigor has set, but not longer; then

3. freeze trunks or fillets or store the trunks in RSW at 1°C for up to 12 h then fillet and freeze.