MUSCLE IRIDESCENCE: POTENTIAL CAUSES – POSSIBLE SOLUTIONS

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Background

Muscle iridescence is a rainbow-like color array associated with pre-cooked meat. It is visually unappealing to consumers who may falsely associate it with bacterial growth or outdated meat. Previous research (Swatland, 1984; 1988) investigated the optical characteristics of iridescence but did not address the potential causes or possible mechanisms to reduce or eliminate this visual phenomenon.

Objectives

The purpose of this research was to investigate causes of and solutions for iridescence in pre-cooked meat products.

Methods

Three projects were conducted to investigate the muscle iridescence phenomenon.

Exp. 1

The first project (Wang, 1991) investigated the effects of physical and chemical modifications, processing variables, and chemical analyses on the iridescent properties of pre-cooked beef slices of *semitendinosus* and *biceps femoris*. Physical modifications tested included dehydration (dried at 50C for 1 h or 100C for 0.5 h or dried in 50 or 100% acetone for 1 h), freezing (-18C), and adding fat (soaked in vegetable oil for 24 h). Chemical modifications of muscle samples included the removal of fat (soaked in formaldehyde, formamide, methanol, ethyl alcohol, ethyl ether or hexane for 24 h) or muscle pigment (soaked in 30% hydrogen peroxide for 3 h). Processing variables tested were added water (3 or 10%), added phosphates (0.3 or 0.5%), final internal endpoint temperature (54.4, 60, 62.8, or 68.3C), slicing temperature (-1.1, 7.2, 48.9, 54.4, or 62.8C), cutting angle (sliced at 0° to 90° to muscle fiber orientation in 15° increments) and sharpness of slicing blade (dull or sharp). Chemical analyses measured the influence of fat content and water holding capacity on iridescence. Further, the effects of observation angle (35° or 55°), lighting angle (70° or 90°), and sample rotation (-90° to +90°) on ability to detect iridescence were investigated.

Exp. 2

The second project (Obuz et al., 2002) investigated the effects of blade tenderization (0, 1, or 2 passes) on the appearance of iridescence in pre-cooked beef *semitendinosus* slices.

Exp. 3

The third project (Lawrence et al., 2002) investigated the effects of surface roughing during slicing (sandpaper adhered to the surface of slicing blade) on the appearance of iridescence in slices of pre-cooked beef *semitendinosus*, *semimembranosus*, and *biceps femoris*.

Results and discussion

Exp. 1

Dehydration or freezing eliminated iridescence, but it reappeared after subsequent rehydration or thawing. Soaking muscle in vegetable oil or removing fat with fat soluble petroleum distillates had no effect on iridescence. Adding more water (10% vs. 3%) or phosphate (0.5% vs. 0.3%) increased iridescence scores. Product endpoint temperature influenced iridescence, with roasts cooked to 60, 62.8, or 68.3C having more iridescence than those cooked to 54.4C, suggesting that structural regularity increases between 54.4 and 60C. In addition, a quadratic effect was noted for slicing temperature; iridescence increased as slicing temperature increased from –1.1 to 7.2 and 48.9C, then declined as slicing temperature was further increased to 54.4 and 62.8C. Cutting angle (in relation to muscle fiber orientation) greatly influenced iridescence. Iridescence was most intense at a 90° (perpendicular) angle and decreased as cutting angle decreased. Iridescence disappeared at a cutting angle below 40°. Furthermore, slices cut with a sharp blade displayed more iridescence than those cut with a dull blade. Iridescence increased as fat content decreased ($r = -0.77$) or as water holding capacity increased ($r = 0.72$). Iridescence was greater for samples observed at a 35° angle than those viewed at 55°. In addition, samples viewed under a light angle of 70° exhibited more iridescence than those examined under a 90° light angle. Moreover, iridescence decreased dramatically as samples were rotated 90° left or right from the point of maximum iridescence.

Exp. 2

Blade tenderization decreased the intensity of iridescence and the percentage of area exhibiting iridescence. The mechanism of decreased iridescence appears to be through changing the structural regularity of the muscle fibers. As the blades penetrate the muscle and cut across fibers, structural homogeneity is decreased, thereby decreasing iridescence.

Exp. 3

Surface roughing during slicing decreased the intensity of iridescence and the percentage of area exhibiting iridescence. The rough texture of the sandpaper physically modified the surface of the cooked beef as the products were being sliced. This "scratching" action decreased the structural homogeneity of the muscle fibers at the freshly cut surface and caused a reduction in the appearance of iridescence. This technology could easily be applied in commercial operations following the advent of a slicing blade with a textured face. In addition, iridescence was greatest for the *semitendinosus*, followed by the *semimembranosus* and the *biceps femoris*. Iridescence in the *biceps femoris* was observed only in the ischiatic head.

Conclusions

Iridescence is a physical phenomenon linked to structural homogeneity at the meat surface, which can be influenced by the addition or deletion of water. Processing procedures such as adding water and phosphates are likely to increase the presence of iridescence. Iridescence increases as fat content decreases and as water holding capacity increases. Iridescence is not affected by the presence or absence of myoglobin. Addition or deletion of a fat layer at the meat surface does not influence iridescence. Cutting at angles less than perpendicular (90°) to muscle fiber orientation decreases the appearance of iridescence. Sharp slicer blades induce more iridescence than dull blades. Blade tenderization causes physical disruption of muscle fibers, which decreases iridescence. Surface roughing during slicing decreases structural homogeneity at the meat surface, thereby reducing iridescence. Iridescence appears greatest in the *semitendinosus* followed by the *semimembranosus* and is least in the *biceps femoris*.

Pertinent literature

Lawrence, T. E., M. C. Hunt, and D. H. Kropf. 2002. Surface roughening of pre-cooked, cured beef round muscles reduces iridescence. J. Muscle Foods. 13: 69-73.

Obuz, E. and D. H. Kropf. 2002. Will blade tenderization decrease iridescence in cooked beef *semitendinosus* muscle? J. Muscle Foods. 13: 75-79.

Swatland, H. J. 1984. Optical characteristics of natural iridescence in meat. J. Food Sci. 49: 685-686.

Swatland, H. J. 1988. Inference colors of beef fasciculi in circularly polarized light. J. Anim. Sci. 66: 379-384.

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TABLE 1. Summary of research conducted at Kansas State University regarding factors that influence the appearance of iridescence (IR).

Muscle treatment	Effect	Comments
Dehydration	IR eliminated	IR reappeared after rehydration
Freezing	IR eliminated	IR reappeared after thawing
Added fat	No effect	Adding or soaking muscle in vegetable oil did not affect IR
Fat removal	No effect	Removing fat with petroleum distillates did not affect IR
Pigment removal	No effect	Pigment removed with hydrogen peroxide, IR remained
Added water	IR increased	10% added water induced more IR than 3%
Added phosphate	IR increased	0.5% added phosphate induced more IR than 0.3%
Internal endpoint temperature	IR influenced	Samples cooked to 60, 62.8, or 68.3C had more IR than 54.4C
Slicing temperature	IR influenced	IR increased as slicing temperature increased from –1.1C to 48.9C then decreased as slicing temperature increased to 62.8C
Cutting angle	IR influenced	IR disappeared at cutting angles less than 40 degrees, and was most intense at a 90 degree cutting angle
Cutting blade sharpness	IR influenced	More IR with sharp blade, less IR with dull blade
Fat content	IR influenced	IR decreased as fat content increased
Water holding capacity	IR influenced	IR increased as water holding capacity increased
Observation angle	IR influenced	IR greater at 35 degree observation angle than at a 55 degree angle
Lighting angle	IR influenced	IR greater at 70 degree lighting angle than a 90 degree angle
Sample rotation	IR influenced	Intensity if IR will change as sample is rotated
Blade tenderization	IR influenced	Blade tenderization (1 or 2 passes) decreased IR
Surface roughing during slicing	IR influenced	Physical surface disruption during slicing decreased IR
Muscle to muscle variation	IR influenced	IR was more evident in the *semitendinosus* than the *semimembranosus*, which had more IR than the *biceps femoris*

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