

Techniques for Measuring Meat Quality

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Summary

Objective measurements of meat quality attempt to quantify its sensory and nutritional values. Existing techniques broadly employ spectroscopic, chemical and mechanical means in one form or another. Appearance and flavor defy representation, whereas force of shear reasonably indicates texture. Composition per se can be measured in many ways to either define or infer contents. Procedures can be divided as either being intensive, specific and limited in conduct or extensive to convey the population but values indirectly relate quality. Intensive measurements are usually associated with establishing its basic meaning to quality, whereas extensive ones favor commercial implementation. Development of extensive-type quality estimates for commercial implementation has dominated recent efforts. Near infra-red and light reflectance are frequent spectroscopic procedures because of rapidity and cost, while thiobarbituric acid and shear commonly represent the chemical and mechanical approaches. Most measurements have not changed in principle as much as become more understood and refined in conduct to better reflect meat quality.

Introduction

Measuring meat quality has the objective of relating its sensory and/or nutrient characteristics in one manner or another. Perceptions of poultry meat quality intricately involve freshness, healthiness, and versatility by the consumer but appearance and convenience appear to be the market drivers (Kennedy *et al.*, 2004). Consistency in such qualities depends on controlling rearing, nutrition, management, and processing through to consumer use (Berri, 2000). While most consumer panels focusing on sensory analysis usually employ standardized procedures to directly estimate quality (Mead, 1987), the spectroscopic, chemical and physical measurements infer quality by quantitatively using one or more facets associated with the senses. Such measurements are invariably less expensive than conducting a consumer panel, and either intensive in their conduct or extensive to provide ease as well as product representation.

Muscle Composition

Magnetic resonance imaging (MRI) has proven useful to provide volume of specific carcass tissues, particularly the pectoral muscle and abdominal fat without necessitating its destruction (Kover *et al.*, 1998). Actual tissue composition has typically relied on the traditional proximate analysis; however, less time consuming and equally acute procedures have been developed. Low intensity ultra sound is reliable for body composition while being simple, fast, and nondestructive (Chanamai and McClements, 1999). Fat, ash, protein and moisture generally have an $r^2 > 0.97$ to actual values. Near-infrared reflectance spectroscopy (NIRA) is an alternative which is predicable for dry matter, protein, lipids, and major fatty acid contents once an operating spectral base has been established, but results are generally poor for ash, pH, color, and determination of lipid oxidation products (Berzaghi *et al.*, 2005).

Spectrophotometric Procedures

Use of light reflectance has generally proven to be more favorable than procedures employing muscle transmittance. Muscle sarcomere length is detectable with transmitted polarized light but obliterated in bulk meat by pH dependant scattering (Swatland *et al.*, 2001). Light reflectance usually involves the CIE $L^*a^*b^*$ scale and proven reasonably

communicative of quality from many aspects. Changes in L* is a good measure of sample lightness-darkness relative to consumers view with minimal interference from product thickness and background color (Sandusky and Heath, 1998; Bianchi and Fletcher, 2002). Very wide differences exist in L* among commercial sources of broilers, and high values are indicative of pale-soft-exudative (PSE) muscle (Wilkins *et al.*, 2000; Petracci *et al.*, 2004; Lesio *et al.*, 2005). Increasing L* relates to increasing moisture, glycogen, iron, ash, and certain fatty acid ratios (Qiao *et al.*, 2002) as much as indicate reduced pH and water holding capacity (Barbut and Mittal, 1993; Fletcher *et al.*, 2000; Owens *et al.*, 2000; Polidori *et al.*, 2000; Qiao *et al.*, 2001; 2002). The correlation between L* and pH is as valid with raw breast muscle as when cooked although correlation was better with the former but variation was less when cooked (Fletcher *et al.*, 2000).

Alteration in muscle pH is known to modify the relationship of protein with water and measuring one or the other provides a meaningful expectation of moisture loss with time and denaturation. Direct measurement of muscle pH is difficult to conduct in given time frame, regardless of procedure (Sante and Fernandez, 2000); however, associated electrical changes permit conductivity measurements to enable parallel estimates of quality (Stephan *et al.*, 1990; Grashorn and Elwinger, 1993). Physically determining moisture expressed from meat using any variant is laborious compared to the simplicity of measuring L* (Earl *et al.*, 1996; Henckel *et al.*, 2003). Moisture losses that occur from protein denaturation as a result of tissue freezing –thawing and cooking are correlated with L* while rapidity permits a reasonable representation of the population (Qiao *et al.*, 2002; Galobart and Moran, 2004ab).

Chromatographic separation of poultry meat volatiles when sequenced with mass spectrophotometry conducted before and after cooking reveals an infinite and differential array of contributors. More than 250-300 separate compounds have been identified from cooked chicken meat (Nonaka *et al.*, 1967; Ramaswamy and Richards, 1982; Noleau and Toulemonde, 1986). While the sulfur containing compounds have been attributed to be the dominant qualitative feature of aroma and flavor (Pippen and Mecchi, 1969; Farbood and Macneil, 1979), diverse hydrocarbons that contribute to the browning reaction and a myriad of sensory characteristics are also apparent (Fors and Olofsson, 1986; Wolm *et al.*, 1988). Boothe and Arnold (2002) described an electronic nose that could detect changes in volatile compounds in stored chicken meat based on storage time and noted that compound diversity increased with temperature.

Irradiation to improve the microbiological quality of poultry meat can also lead to changes that adversely affect its sensory value. Chromatographic analysis of by-products from irradiation generally indicate a dramatic increase of sulfide type compounds while a variety of aldehydes appears to a lesser extent (Patterson and Stevenson, 1995). Fan *et al.* (2002) used solid phase microextraction of volatile sulfur compounds from cooked turkey breast followed by their gas chromatographic separation and noted that irradiation dramatically increased hydrogen sulfide, sulfur dioxide, methanethiol, and dimethyl sulfide while carbon disulfide was reduced. Visually, an increased redness was also apparent which could be measured either as a spectroscopic shift related to myoglobin changes or as increased a^* with light reflectance (Nanke *et al.*, 1998; Liu *et al.*, 2003). Measurement of $+a^*$ values appear to superimpose of all "red" factors and would include those arising from the browning reaction and thiobarbituric acid reactive substances (TBARS) that also result from aldehydes but concomitantly provided by other aspects of lipid oxidation (Du *et al.*, 2000; Nam and Ahn, 2003).

The a^* and b^* scales associated with light reflectance also enables a convenient estimate of differing degrees blood splash, bruising and/or death of raw muscle. Color changes occurring from vascular trauma may appear as red from hemoglobin through to blue, yellow green of its progressive degradation products, and their actual amounts could not otherwise be measured without extended analyses (Hamdy *et al.*, 1961; Lyon *et al.*, 1986). While the $+a^*$ scale indicates redness, the $-a^*$ CIE scale provides an estimate greenness, the $+b^*$ can relate yellowness with the $-b^*$ giving blueness. Taken together, a^* and b^* can be used to integrate the extent and age of muscle insult when compared to an appropriate control.

Chemical Procedures

Flavor changes related to oxidation of lipids is a predominant threat to poultry meat quality. Deterioration of unsaturated fatty acids with the evolution of aldehydes, ketones, and monocarbonyls dominates to yield various off to fishy flavors (Harris and Lindsay, 1972; Meijboom and Stroink, 1972; Ruenger *et al.*, 1978; Moerck and Ball, 1979). While these lipid oxidation products can be chromatographically measured, the use the thiobarbituric acid method (TBA) has been preferred because of its simplicity (Raharjo and Sofos, 1993). The warmed-over flavor in cooked and poorly stored poultry meats is well related to TBA values (Wilson *et al.*, 1976; Lyon *et al.*, 1988; Lai *et al.*, 1995). Inclusion of additional antioxidants with sensitive lipids can substantially relieve adverse flavor problems in a

manner inversely correlated with TBA values (Sheldon *et al.*, 1997; Carreras *et al.*, 2004; Sarraga *et al.*, 2006). The TBA reaction in the traditional manner yields a red color with maximum at 530 nm that is specifically due to malondialdehyde and only generated with fatty acids having two or more double bonds. Marcuse and Pokorny (1994) note that before the formation of the red color, a transient yellow color at 450 nm, corresponding to similar reactions with alkanals, alkenals, and alkendials is also apparent. Such yellow measurement would give a broader estimate of total oxidation products, particularly those from low unsaturated fatty acids and is better correlated with sensory evaluation than occurs with the red.

Physical Methods

Measurements employing physical manipulations of meat are dominated with attempts at mimicking the work of mastication to objectively estimate tenderness. Force required to shear a portion of muscle has large employed Kramer type compression cells where variation in blade number, size and shape are involved. Generally, all these methods correlate with subjective sensory panel estimates (Simpson and Goodwin, 1974; Timber *et al.*, 1985; Heath and Owens, 1997; Lyon and Lyon, 1996;1998). Although using multiple blades appear to provide more reliable values than with a single blade, needle puncture and raor blade shear avoid the complications of sample size (Mast *et al.*, 1981; Cavitt *et al.*, 2005). Myofibrilar fragmentation index microscopically estimates cellular structural integrity; however, it does not correlate with tenderness as well as shear that was conducted on a macro basis (Sayre, 1970; Kriese *et al.*, 2007). Practical application of any macro-shear procedure shear is most applicable to estimating the extent of post-mortem rigor and consumer satisfaction as sex, strain, nutrition, and age of bird influences are minimal (lyon and Lyon, 1990; Lyon and Lyon, 1997; Poole *et al.*, 1999).

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