Measuring Water-Holding Capacity in Post-Rigor Muscle

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Within the meat science-based literature, a substantial discussion has developed which is concerned with the physical properties of meat as they impact sensory perception. One of the most important of these is water-holding capacity (WHC) which relates to the juiciness and thus palatability of the cooked meat product. The purpose of this session was not to summarize this body of literature or to discuss the potential theoretical bases for observed differences in WHC. Rather, it was the intent of the presenters to provide an overview of the various laboratory methods which can be used to measure this phenomenon.

Water-'HOLDING' capacity is defined as the ability of post-rigor muscles to chemically and/or physically 'HOLD' the fluids inherently associated within them. Differences in WHC are readily observed in samples of pork which are pale, soft and exudative (PSE; low WHC) or dark, firm and dry (DFD; high WHC) (Figure 1).

A second term used to describe water retention by meat is water-BINDING capacity (WBC). WBC is defined as a muscle's ability to 'BIND' external fluids when soaked or homogenized in, or pumped with these fluids (Figure 2).

Muscles from most species of meat animals vary somewhat in their WHC but pork exhibits extreme variations. Even within an animal, factors such as stress, genetics, muscle type and post-mortem pre-rigor chilling rates affect WHC.

WHC is one of the most important meat quality traits because it affects:

1. yield of products during processing
2. retention of nutrients
3. appearance during retail display
4. juiciness (and perhaps tenderness) of cooked products.

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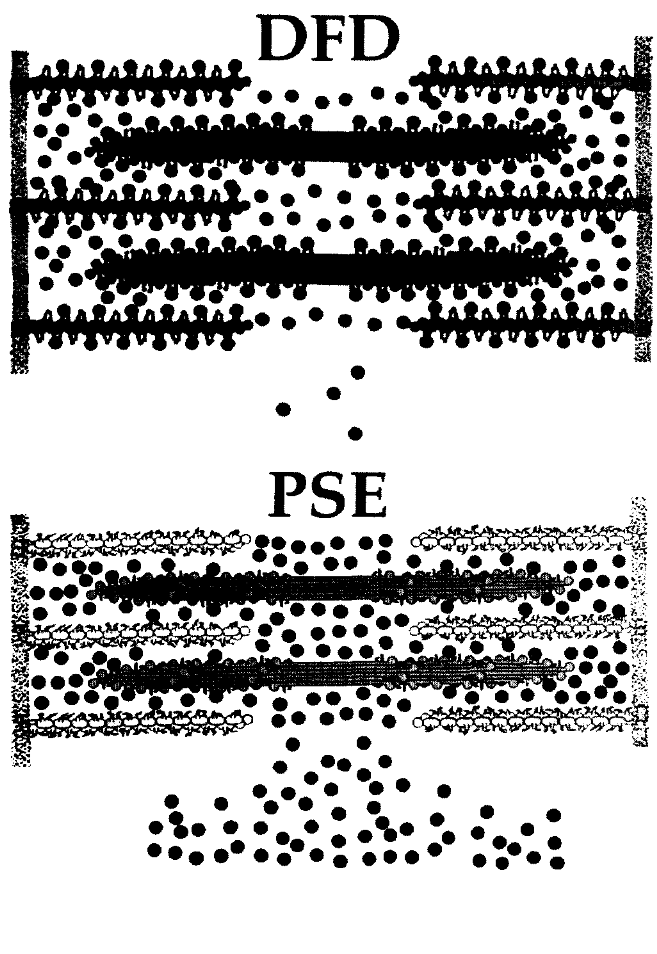
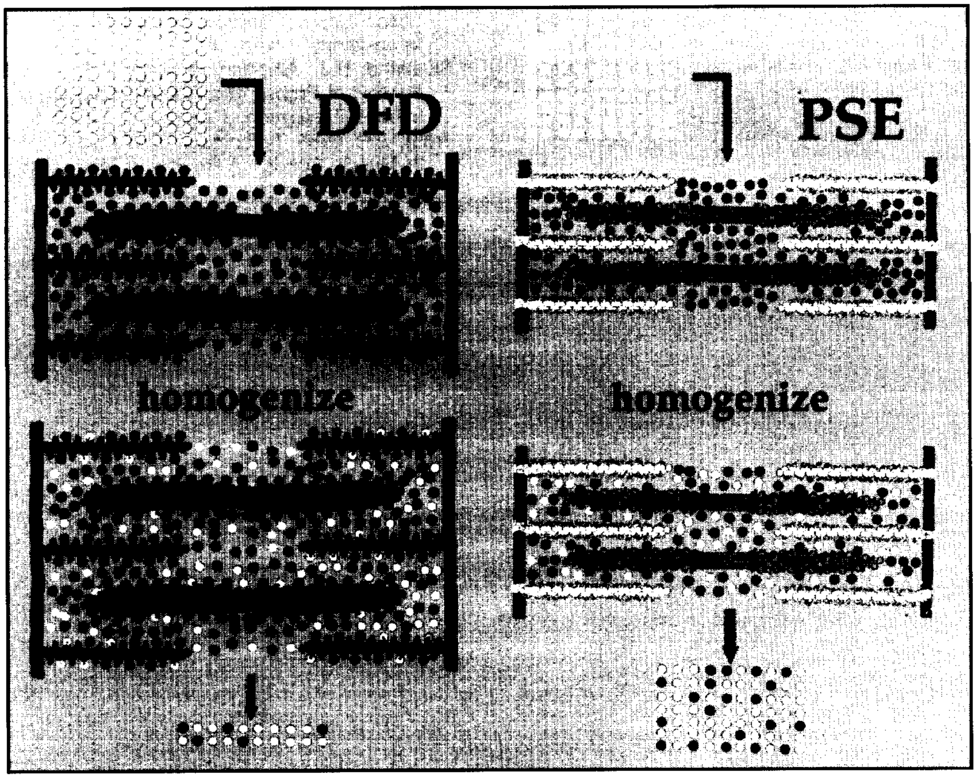
A summary of 16 methods that either assess, describe or help explain WHC of fresh post-rigor muscles is presented in Table 1. These methods include physical, electrical, optical, chemical and scoring approaches. A subjective assessment of the accuracy and reproducibility, invasiveness, cost, speed, ease of application, advantages and limitations has been provided.

Figure 1
Comparison of Water-Holding Capacity Between:



Diagrammatic representation of differences in water-holding capacity between dark, firm and dry (DFD), and pale, soft and exudative (PSE) pork. Filled circles represent water molecules.

Figure 2
Comparison of Water-Binding Capacity Between:



Diagrammatic representation of water-binding capacity in dark, firm and dry (DFD), and pale, soft and exudative (PSE) pork. Filled circles represent water molecules endogenous to the meat; white circles represent added water.

Table 1. A Subjective Comparison of Methods to Determine and/or Explain Water-Holding Capacity in Meat.

CATEGORY	*Method*	*Origin*	*Invasive*	*Accuracy*	*Cost*	*Speed*	*Approach*	*Advantage*	*Limitation*
I. PHYSICAL	1. Pressure	Grau-Hamm (1953)	no	medium	low	rapid	easy	cost	accuracy
	2. Gravity	Honikel (1985)	no	very high	low	slow	easy	accuracy	speed
	3. Centrifuge	Wierbicki (1962)	no	high	medium	slow	easy	for binding	speed
		Bouton (1971)	no	high	high	slow	easy	accuracy	speed
	4. Absorption	Lundstrom (1985)	no	very high	low	slow	easy	accuracy	speed
		Kauffman (1986)	no	high	very low	rapid	easy	speed/cost	humidity
		Zhang (1994)	no	medium	very low	rapid	easy	cost	accuracy
	5. Capillarity	Hofmann (1975)	no	low	medium	rapid	easy	none	accuracy
	6. Imbibition	Hass (1984)	no	low	very low	rapid	easy	speed/cost	accuracy
	7. Suction	Kim (1994)	yes	high	low	slow	easy	invasive	speed
II. ELECTRICAL	8. Conductivity & Resistance	Swatland (1980)	yes	medium	low	rapid	easy	invasive	accuracy
	9. Capacitance	Grant (1978)	no	low	high	slow	complex	none	accuracy
III. OPTICAL	10. Reflectance	Swatland (1980)	yes	medium	medium	rapid	easy	invasive	RSE vs RFN?
	11. Light Scatter	McDougall (1976)	yes	medium	medium	rapid	easy	invasive	RSE vs RFN?
IV. CHEMICAL	12. pH	Briskey (1964)	yes	medium	medium	rapid	easy	invasive	RSE vs RFN?
	13. Transmiss.	Hart (1962)	no	medium	medium	slow	complex	PSE	RSE vs RFN
	14. Protein Sol.	Warriss (1986)	no	medium	medium	slow	complex	PSE	vs DFD
	15. NMR	Tornberg (1986)	no	high	very high	slow	complex	accuracy	cost
V. SCORING	16. Firmness	Nakai (1975)	no	medium	very low	rapid	easy	speed/cost	subjective

References

Kauffman, R.G.; Eikelenboom, G.; van der Wal, P.G.; Engel, B; Zaar, M. 1986. A Comparison of Methods to Estimate Water-Holding Capacity in Post-Rigor Porcine Muscle. Meat Sci. 18:307-322.

Offer, G; Knight, P. 1988. Chapter 3. The Structural Basis of Water-Holding in Meat. Part 1: General Principles and Water Uptake in Meat Processing, and Chapter 4. Part 2: Drip Losses. In *Developments in Meat Science.* R. A. Lawrie (ed.) Elsevier App. Sci. Publ., Essex, UK. pp 63-243.

Puolonne, E.; Demeyer, D.I. 1993. Pork Quality: Genetic and Metabolic Factors (Chapters by Honikel, Tornberg, Swatland). C.A.B. International, Oxon, UK.

Swatland, H.J.; Anathanarayanan, S.P.; Goldenberg, A.A. 1994. A Review of Probes and Robots: Implementing New Technologies in Meat Evaluation. J. Anim. Sci. 72:1475-1486.

Trout, G.R. 1988. Techniques for Measuring Water-Binding Capacity in Muscle Foods - A Review of Methodology. Meat Sci. 23:235-252.